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RELATIONSHIP BETWEEN GOLD AND COPPER METALLOGENESIS IN THE METALIFERI MTS.

GHEORGHE C. POPESCU[1], ANTONELA NEACŞU[1]

[1]University of Bucharest, Faculty of Geology and Geophysics, Department of Mineralogy, 1, N. Bălcescu Blvd., 010041, Bucharest, Romania

Abstract

Several "porphyry copper" structures have been discovered in the Metaliferi Mts. during the 70s, some of them of real economic value (i.e. Roşia Poieni, Bolcana). The Roşia Poieni ore deposit represents the largest Cu-Au porphyry structure in the Metaliferi Mts., matching in celebrity the gold-silver deposit at Roşia Montana, located at approximately 4 km. The existence of some paleo-calderas in the Metaliferi Mts. has recently been recognized in the Roşia Montana district (O'Connor et al., 2004) and in other perimeters. It is very probable that such calderas have functioned as complex, circular-shaped calderas which hosted hydrothermal activity. Such activity may have mobilized pre-concentrated mineralization lying around apical plutons of K_2 (Marcoux et al., 2002) or Precambrian age. This genetic scenario explains well the fundamental characteristic of the metallogenesis in the Metaliferi Mts.

Keywords: porphyry structure, vertical zoning, periplutonic zoning, hypogene zoning, Emmons zones, caldera-type structures

The most important and renowned metallogenic unit of Romania is the Neogene province of Apuseni Mts., also known morphological unit of the "Metaliferi Mountains" or, form a geographical-metaphoric point of view – the "Golden Quadrilateral". Evidence of gold mining goes back to antiquity – especially from the period of Roman

[1]e-mail:ghpop@geo.edu.ro

occupation of Dacia (the Dacian thesaurus during king Decebal was of approx. 165.000 kgs; during the 168 years of occupation (106 A.D. – 274 A.D) the Romans have mined about 450.000 kgs (Brana, 1958).

The first coherent and modern picture of geology and mining in the Metaliferi Mts. was given by Ghiţulescu and Socolescu in 1941, who wrote an evergreen monograph on the area. This valuable work was the first to present a convincing analysis of the relationships between the gold-silver metallogeny and the Neogene volcanics in Metaliferi Mts.

This work also described a vertical metallogenic zoning of several ore deposits (such as Săcărâmb) where the surface gold-silver mineralization gradually passes to a Pb-Zn mineralization, in depth (fig. 1).

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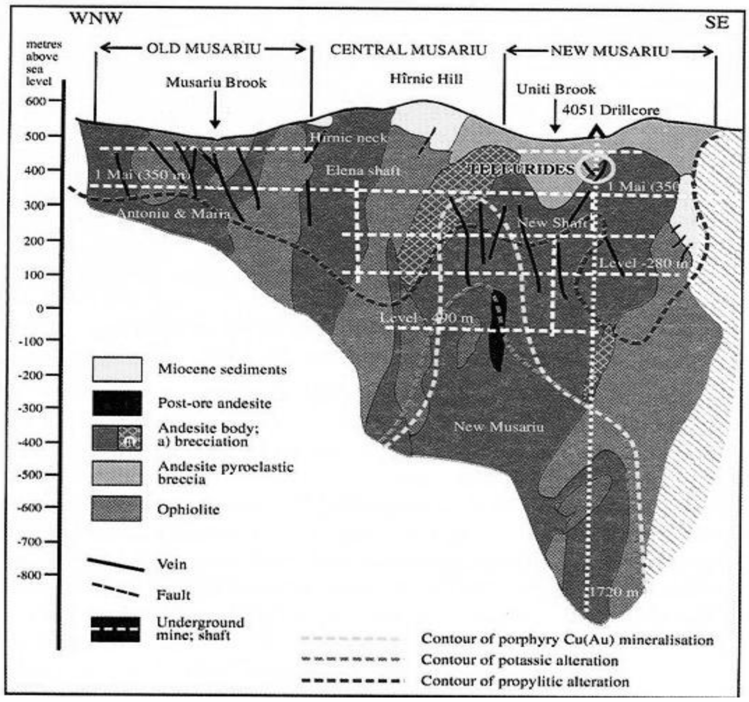

Fig.1 Profile across the Musariu deposit, showing the relationship between the porphyry and the veins (Berbeleac et al, 1995 a) in Ciobanu et al, 2004.

Over 10 porphyry copper structures exist in the Metaliferi Mts., almost all of them located in the surroundings of Au-Ag areas. Some of the most illustrative examples are given by the Musariu-Brădisor structures, Valea Morii-Ruda Barza and Bolcana-Troita-Trestia. In all mentioned cases the porphyry copper structures host gold-silver epithermal veins (fig. 2). Such situations have been explained to represent an argument for a lateral transition from Cu-Au to Ag-Au mineralization, sometimes via a Pb-Zn mineralization (i.e. Măgura-Hondol) (fig. 3).

Direct observations of the ore deposits which have been mined during 1960 and 1990 have shown a vertical zoning with Au-Ag, sometimes Au-Te, in the upper areas, Pb-Zn-Au-Ag in the intermediate levels and Cu in depth (Borcos, 1994).

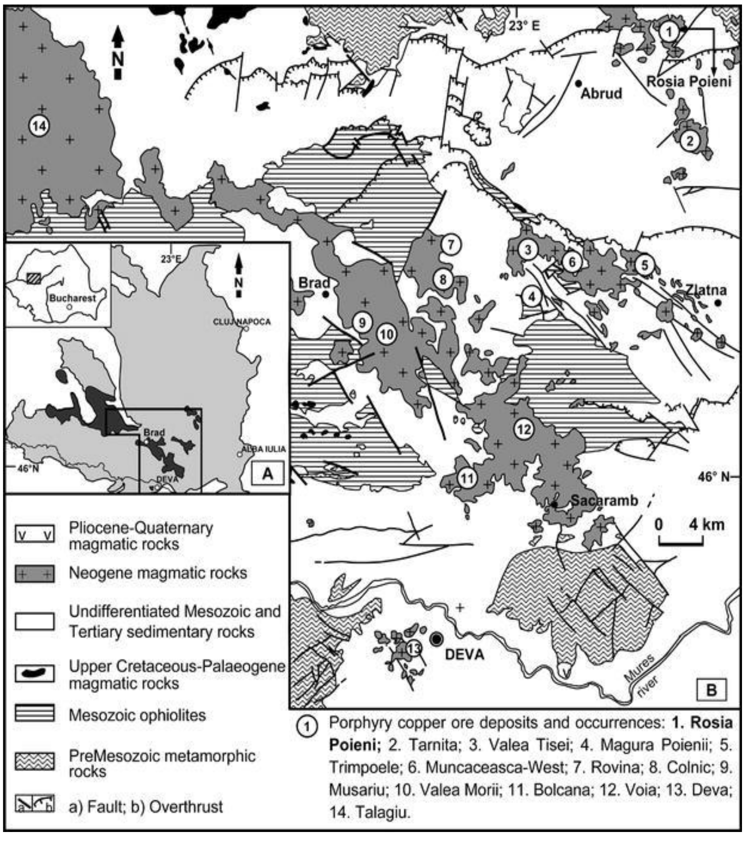

Fig. 2 Simplified geological map of South Apuseni Mts. showing the location of porphyry Cu (Mo, Au) ore deposit occurrences (after Dumitrescu and Săndulescu, 1978 and Bostinescu, 1984) in Milu et al., 2002)

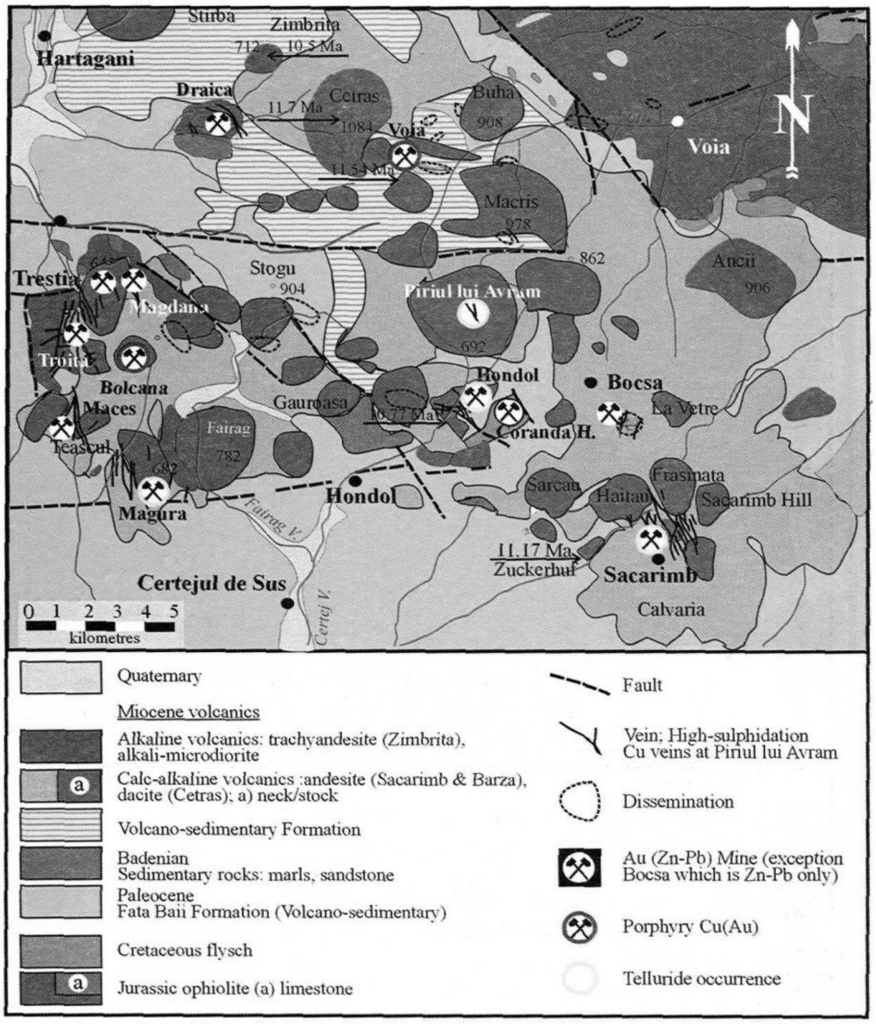

Fig.3 Deposit locations on the geological map of the Sacaramb – Bolcana – Hartagani area, compiled from Ghitulescu and Socolescu, (1941), Udubasa et al. (1992), the "Geological Map of South Apuseni Mountains, Alpine Magmatism and related Ore Deposit" (IGR, 2001), K/Ar ages from Rosu et al. (1997, 2001) in Ciobanu et al., 2004

It is generally accepted that this is a case of periplutonic zoning. A convincing argument may be represented by several underground micro-diorite bodies beneath some mineralized areas. However, drill works carried out as far, down to 1-1.3 km, have not intercepted plutonic bodies elsewhere than the Zlatna-Stănija district and Brad metallogenic field. This hinders the generalization of this model to the scale of Metaliferi Mts (Ciobanu et al., 2004).

In addition, this model does not explain the circular disposition of the gold-silver mineralization around the porphyry copper centers (cores), as observed in the largest part of Metaliferi Mts.

A possible tectonic explanation of the association between porphyry copper and gold-silver mineralization was given by Berger and Drew in 1997 (in Ciobanu et al., 2002). The authors stated that the presence of porphyry copper mineralization is favored by a tensile deformation within ore deposits affected by strike-slip faulting. Vein deposits have formed in brittle deformed spaces, in the so-called "vein mesh". The model may be objectionable in the sense that it does not explain the ring zoning of gold-silver mineralization around the porphyry-copper cores.

A satisfactory explanation of the spatial relationship between the two types of mineralization needs to take into account both the field reality and the metallogenic zoning concept.

The field observations reveal that within several metallogenic fields a hydrothermal activity has taken place: gold-silver on the one hand and copper-gold on the other. The both types of mineralization occur at practically the same erosion level, without significant differences in depth. This mode of occurrence apparently contradicts the vertical zoning which is a characteristic feature of several mineralized structures in Metaliferi Mts. At the time he drafted the theory of hypogene zoning of hydrothermal veins and of post-magmatic ore deposits, Emmons, 1924, (in Popescu,1981) took two principles into account:

1. Hot ascending solutions, reach in mineral substances, precipitate minerals in the cold apical areas, in reversed solubility order.
2. Mineralogical composition variations in ore deposits located at increasingly larger distances from the intrusions are similar to those intercepted in depth (in a single mineralized body – we should add).

Thus, the vertical downwards sequence is similar to the horizontal outwards sequence, which reveals the logic of the Cu-Au metallogenesis centered in the metallogenic fields and of Au-Ag one, towards the outskirts of the ring structures.

As established by Emmons, up to 16 mineral zones may exist in an intrusion related space. This scheme was later corrected by Fersman, 1934, (Routhier, 1963) who recognized the Emmons zones only for the apical sector of granitic plutons. Laterally, the external apical areas descend on the flanks and cover the preceding zones. Thus, on the same level erosion one may encounter zones that are normally seen at different depths. This may explain why in the case of Metaliferi Mts. similar erosion levels display a combination of porphyry copper, gold and silver which would normally appeared as various depths in unitary vein structures.

In the particular case of the Metaliferi Mts. we consider that the ring zoning described above, may be explained by the specific association between metallogenesis and volcanic formations (fig. 4). In turn, the copper metallogenesis is located in subvolcanic bodies occupying the center of caldera-type structures. The existence of some paleo-calderas in the Metaliferi Mts. has recently been recognized in the Roşia Montana district (O'Connor et al., 2004) and in other perimeters (fig 5). It is very probable that such calderas have functioned as complex, circular-shaped calderas which hosted hydrothermal activity. Such activity may have mobilized pre-concentrated mineralization lying around apical plutons of K_2 (Marcoux et al., 2002) or Precambrian age (fig. 6).

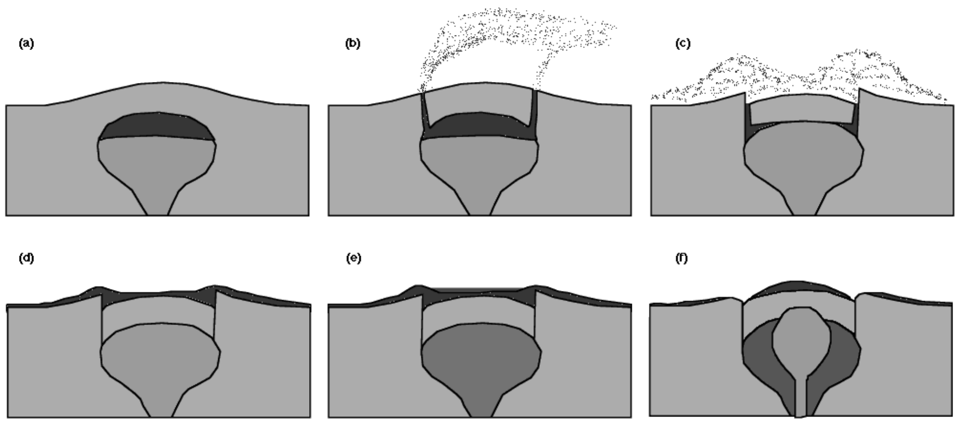

Fig.4 The evolution of a resurgent caldera : a) after an eruption begins and collapse is initiated, ring shaped fractures propagate out of the chamber and burst to the surface; b) the upper part of the magma chamber froths, expands and flows up the vent; magma from the deeper parts of the chamber begins to flow out and the rocks overlying the magma begin to collapse along the fractures into the now emptied chamber; c) pyroclastic flows continue as the initial burst of ash and deeper parts of magma flow across the surface covering the caldera; d) the magma chamber is then depleted in gases and a minor volcanic activity can persist; e) the magma continues to slowly rise; f) the crater floor is pushed up forming a giant ''blister'' (www.solarviews.com)

This genetic scenario explains well the two fundamental characteristic of the metallogenesis in the Metaliferi Mts.:

- The bimodal character of the gold-silver and copper mineralization. In this sense, it is worth mentioning the lack of significant concentrations of other metals (Bi, W, Mo, Sb) which would have been normal in a periplutonic zoning that has developed synchronously with the volcanism.
- The linear pattern of gold-silver metallogenesis around porphyry copper stock cores. The constant gold content may be explained not only by the mobilization

of copper rich apical areas of pre-Neogene intrusions, but also of the newer gold-silver zones. In the same manner, one may question the gold-silver mineralization which passes to deeper polymetallic and copper concentrations resulting from mobilizations of corresponding areas around the pre-Neogene plutons and downwards their flanks.

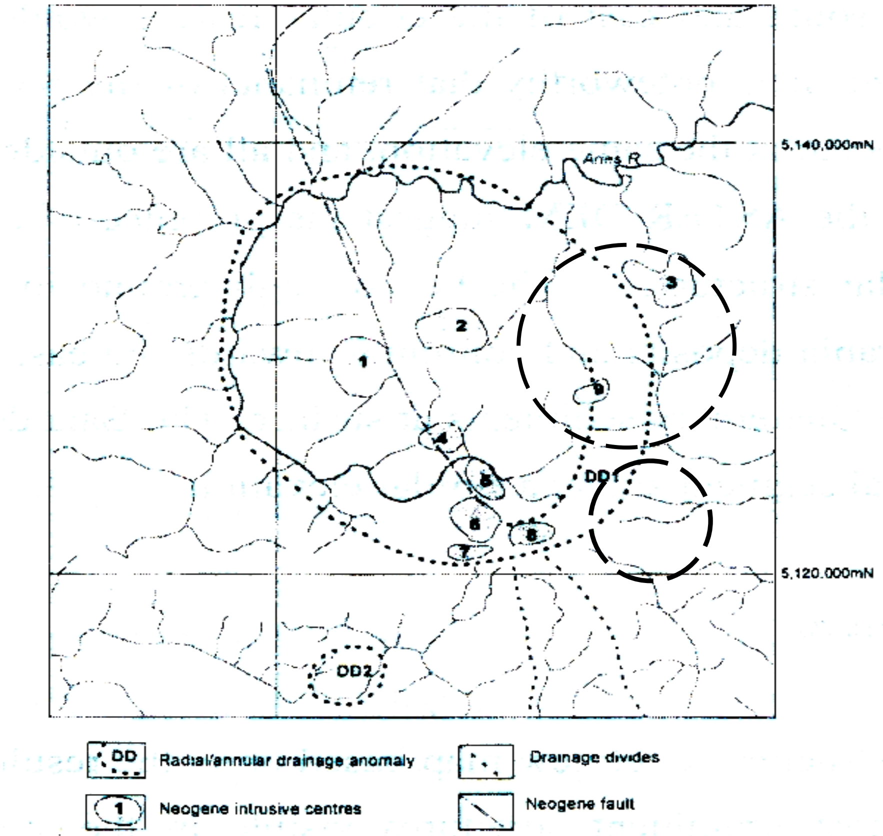

Fig.5 The hypothetical contour of the Roşia-Bucium paleocaldera and the mineralized structures into the Roşia-Bucium District (O'Connor et al., 2004). The paleocalderas Roşia Montana-Roşia Poieni-Frasin and Bucium were modified based on the relationship between the porphyry-copper metallogenesis and the Au-Ag metallogenesis. 1. Roşia Montana, 2. Roşia Poieni, 3. Baia de Arieş, 4. Rodu-Frasin, 5. Bucium-Arama, 6. Bucium-Tarnita, 7. Botes, 8. Vulcoi-Corabia, 9. Geamanasalut.

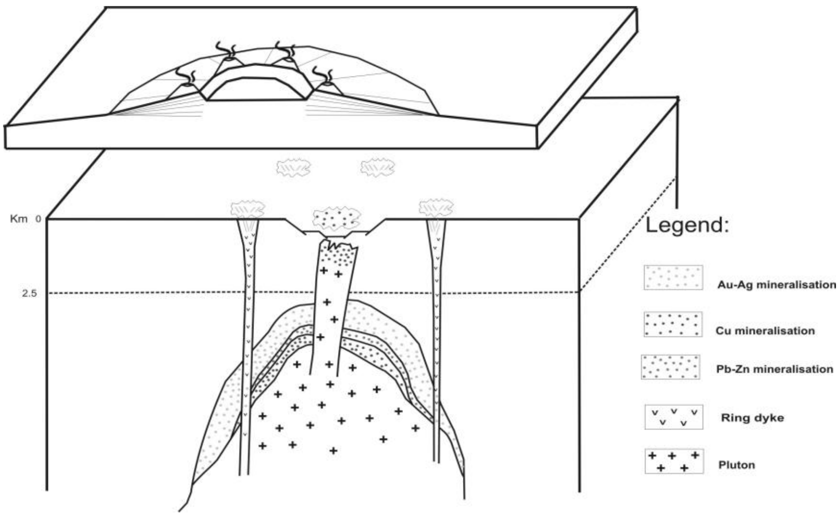

Fig 6 Ring zoning of Cu-Au and polymetallic mineralization related to caldera structures (proposed model)

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