New approaches regarding the geodynamic constraints of Late Cretaceous magmatism in Carpathian area

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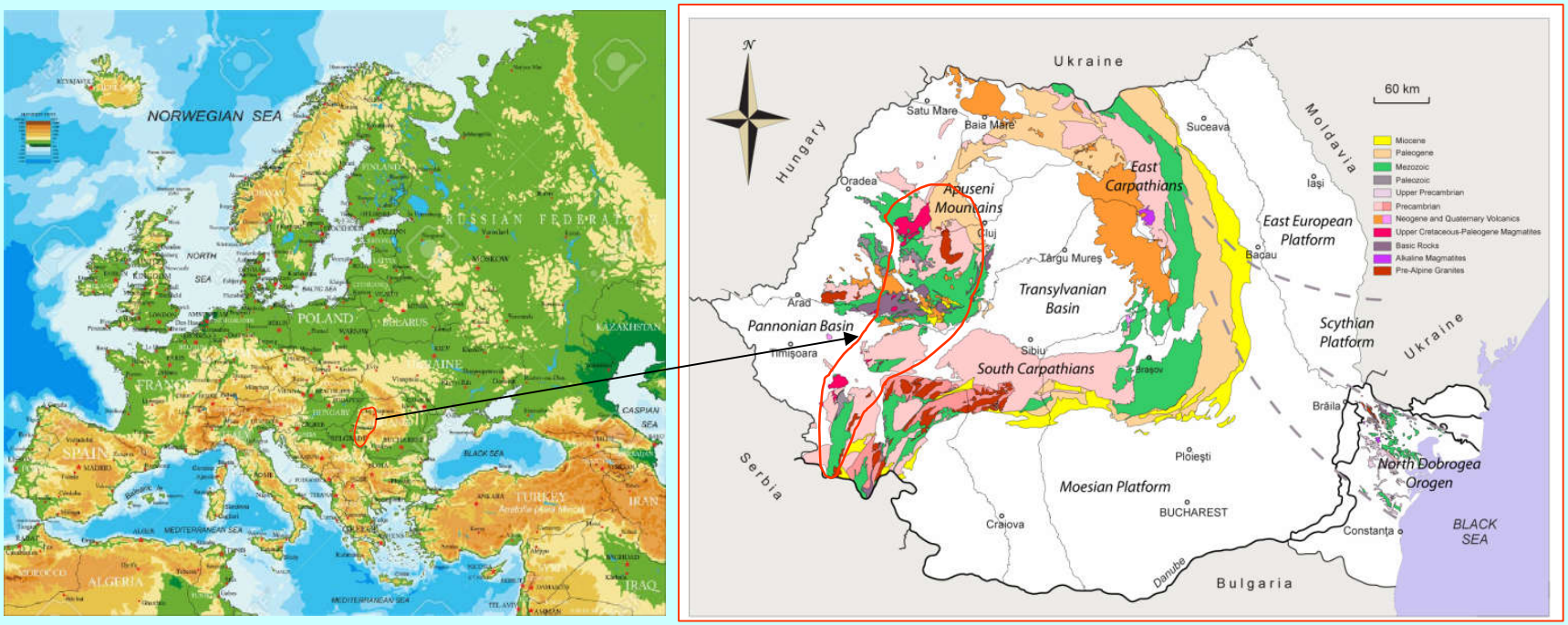
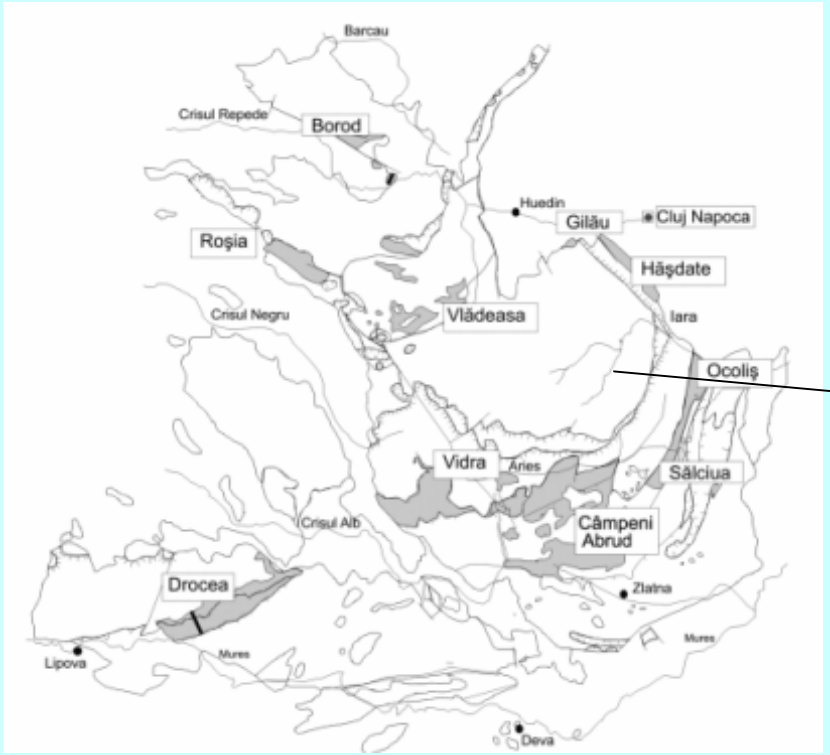
Geological background

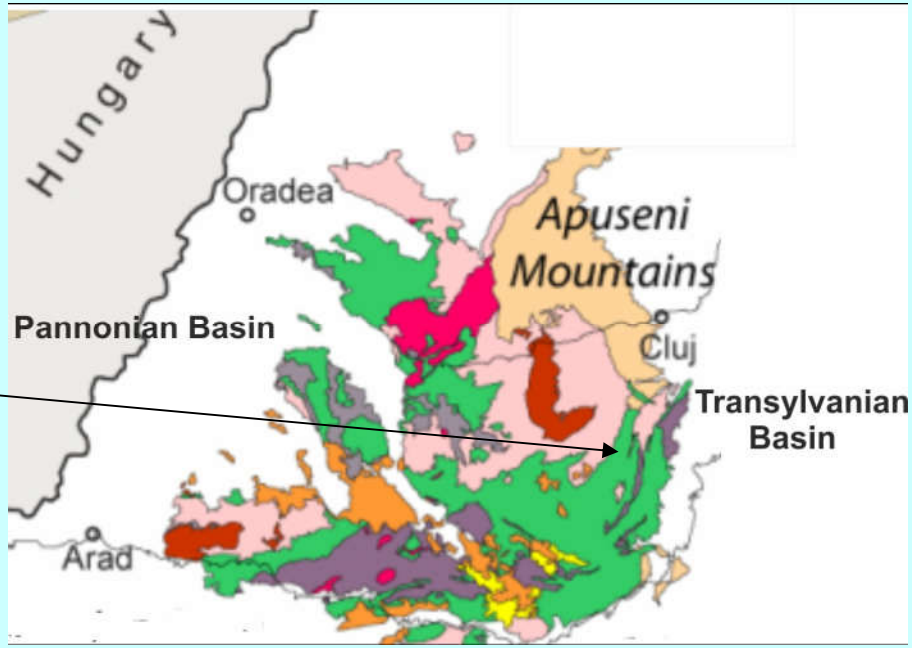


In the Carpatho-Balkan and Pontic-Anatolian areas, the subduction of Tethis in the middle of the Jurassic was followed by a series of tectogenic events that culminated in the Upper Jurassic and Lower Cretaceous with discontinuous, lacunar obductions in the entire mentioned area, after which, in Albian, within this area are accumulated molasses deposits that seal the Middle Cretaceous orogeny (Săndulescu, 1984).

During the Meso-Cretaceous compressive tectonic event (marked by the subduction of the East European Platform under Gondwana, and the initiation of the creation of accretionary prism in front of the orogen) the absence of related magmatism, and implicitly, the lack of an "arc" is similar to that of the Alps (McCarthy et al., 2018).

Geological background



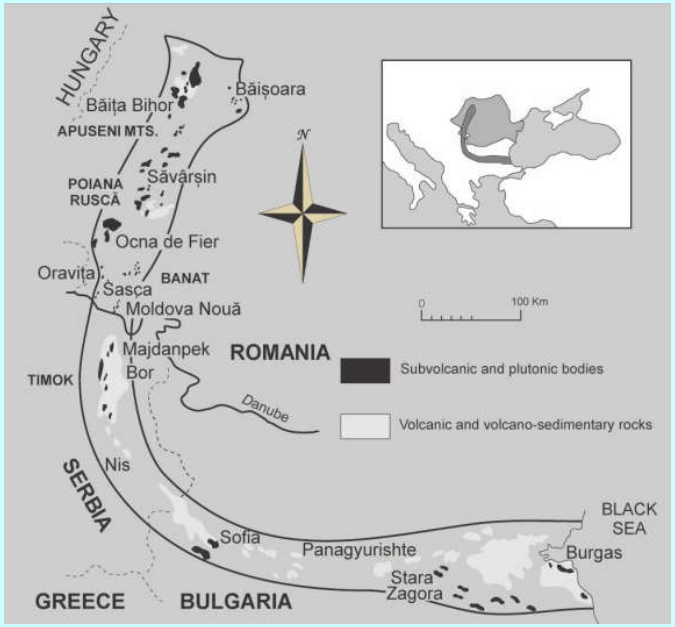


Gosau basins type distribution in the Apuseni Mountains (Schuller, 2004)

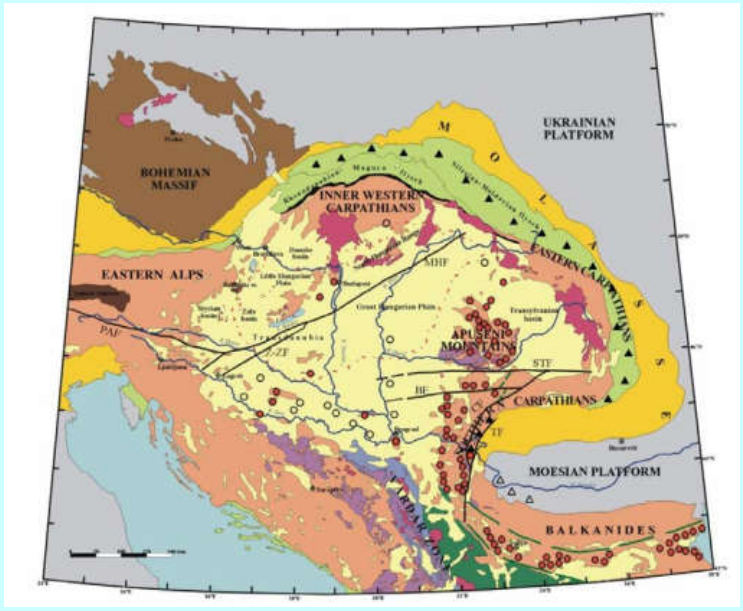
Afterward, in the Upper Cretaceous, the Carpathian area has evolved in an extensional geodynamic context, specific to post-collisional periods, marked by the appearance of sedimentary basins with complex evolution and Gosau type molasses (Schuller, 2004; Schuller et al., 2009).

This context was controlled by the existence of deep fractures, sometimes lithospheric, sin- or post-sedimentary trastensive-transpressive fractures, which later represented the access roads for magmas with a remarkable textural and compositional diversity.

Spatial distribution of Late Cretaceous magmatism



Distribution of the Banatitic Magmatic and Metallogenic Belt in Romania, Eastern Serbia and Bulgaria (in dark gray medallion). Simplified after Cioflica & Vlad (1973).



The distribution of Late Cretaceous intrusions and volcanics in Carpathian – Pannonian and Balkans area, in outcrops (red circles) and borehole (white circles). In external part of Carpathians and Balkans the tuffs of similar age were observed in outcrops (black triangles) and in borholes (white triangles) (Berza in Ilinca et al., 2011; tectonic units after Pancardi Group).

In connection with appearance of Gosau type basins, or not, a complex magmatism has evolved, from a compositional point of view and as manifestation, largely calc-alkaline, known in the geological literature as banatitic (von Cotta, 1864).

Compared to the “L”-shaped distribution (Cioflica & Vlad, 1973) that suggested a magmatic arc-type “belt”, the new image of the banatites (Berza in Ilinca et al., 2011) shows a random spread in the northern half of the province (Hungary, Slovenia, Croatia and Serbia).

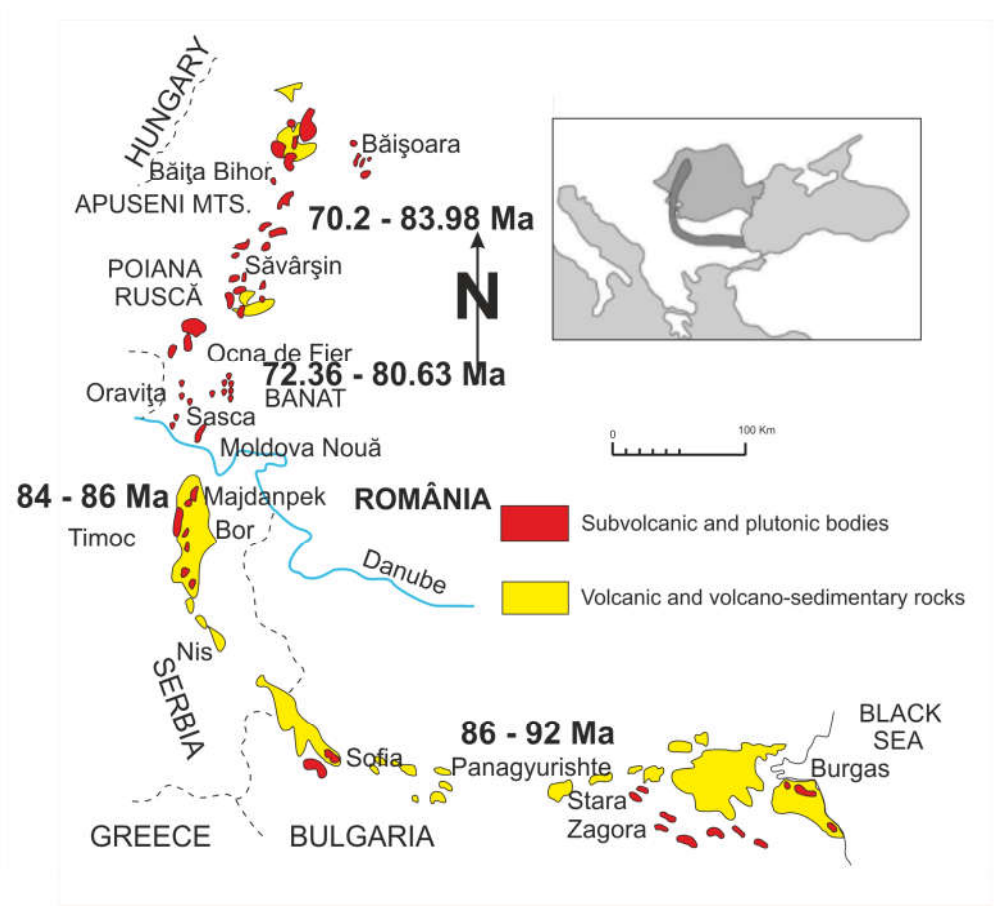
Spatial distribution of Late Cretaceous magmatism

Geological map of Romania, scale 1: 200000 (Geological Institute of Romania); with red dotted areas the outcrop areas of banatites.

It is known that in connection with these intrusions there are a series of ore occurrences in the Apuseni and Banat Mountains (Pietroasa, Budureasa, Băiţa Bihor, Cacova Ierii, Maşca Băişoara, Ocna de Fier, Dognecea, Oraviţa, Ciclova, Sasca, Moldova Noua, etc.) characterized by "high tech metals" mineralizations of W, Mo , B, Mg, Te, Bi, Sb. Along with these elements appear Au, Ag and Cu, Pb, Zn, Fe. The accumulations of these elements are mainly concentrated in contact with carbonate rocks of different ages from different tectonic units that the magmatites in question pass through and their hydrothermal solutions metasomatizes them generating so-called skarns.

In many previous works, the Banatites from the Apuseni to the Balkans are schematically represented with an L-shaped spatial distribution, but, in detail, they occupy areas with some geometry, in the northern and southern part of the Apuseni Mountains, Southern Carpathians (Poiana Ruscă Mountains) and Banat. The term alignment is rather outlined in the last region, where the intrusions and associated metal accumulations have north-south linear orientations.

Timing of magmatism



Simplified sketch with Late Cretaceous magmatism distribution in Romania, Serbia and Bulgaria (after Cioflica & Vlad, 1973)

Banatitic magmatism is the first such manifestation in the Carpathians, post-subduction and post-collision and the most reliable age data (using U-Pb on zircon and Re-Os on molybdenite methods) suggest a very narrow range of evolution (70.2 - 83.98 Ma, Nicolescu et al., 1999; Galhofer, 2015; 72.36 - 80.63 Ma, Ciobanu et al., 2002; Zimmerman et al., 2008), that is characteristic to short-lived magmatism.

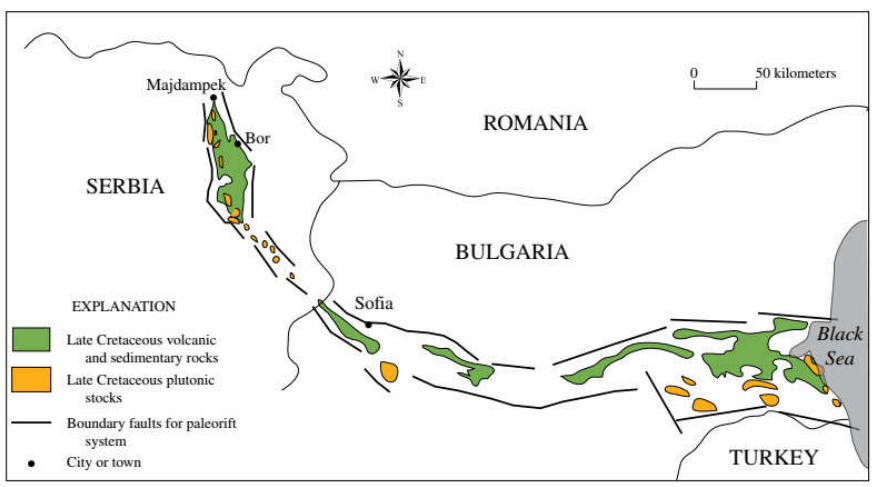
Comparatively, in Serbia (Bor-Madjanpek district), the same magmatism occurs between 84-86 Ma, in Bulgaria in the Srednogorie massif between 86-92 Ma and Rhodope massif at 67-70 Ma (von Quadt et al., 2007).

Geodynamic constraints

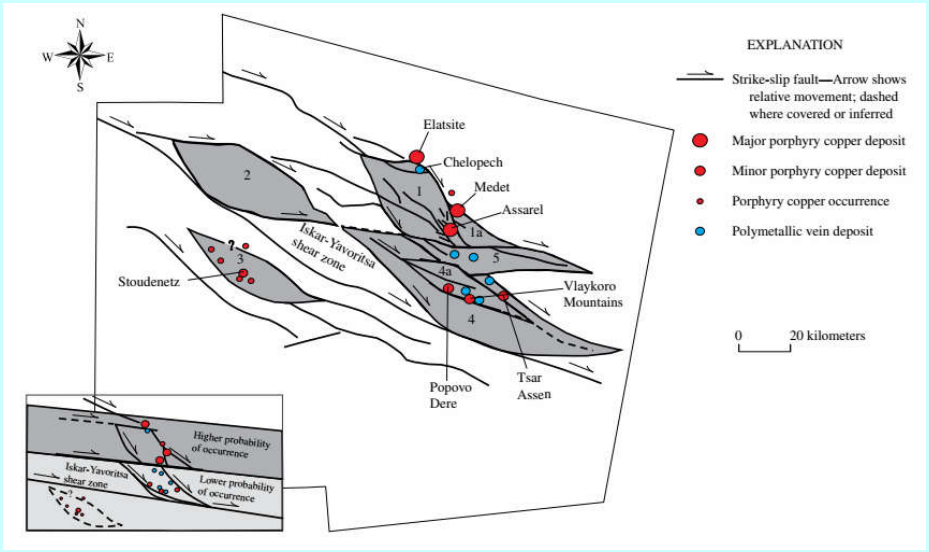
Along with the geographical configuration of the banatites in the Carpatho-Balkan area, there are some aspects related to the relationship between Gosau-type deposits in the extension basins and intrusions and / or extrusions. There are numerous situations in the Apuseni Mountains and in Banat where the access roads of the Late Cretaceous magmatites are precisely the dislocations that favored the development of Gosau type extension basins. At the time of the Upper Cretaceous there were a whole series of deep fractures, some lithospheric, which favored the rise of magmas in the crustal surface. However, we have situations like the one in Vlădeasa, and not only, in which the Gosau type sedimentary deposits were “suspended” at high altitude, located “behind” of granodiorite intrusions. This is an aspect described for situations of the same age in the mainland block of North China by Lin & Wang (2006).

There are two possibilities to explain this situation in the Upper Cretaceous of the Apuseni and Banat Mountains according to the authors mentioned above: (1) mechanical convective ablation of the lithosphere, as Bird (1979) suggests for North American mountain ranges, or (2) the detachment of a large piece of lithospheric mantle as proposed by Houseman et al. (1981). Regardless of the model adopted, thin crust can be explained in an extensional context that facilitates rapid ascents of magmas generated by adiabatic expansion at the base of the lithosphere and / or in the asthenosphere as well as particular aspects related to the presence of suspended Gosau-type basins. At the same time, we have the possibility to explain a significant elevation and the development of plateaus such as the one in Vlădeasa (Merten et al., 2011). Similar aspects are presented for the Sredna Gora massif (Bulgaria), where the transpressive-transtensive structures responsible for the formation of pull-apart basins represented the main drainage channel for Late Cretaceous magmatites (Georgiev et al., 2009).

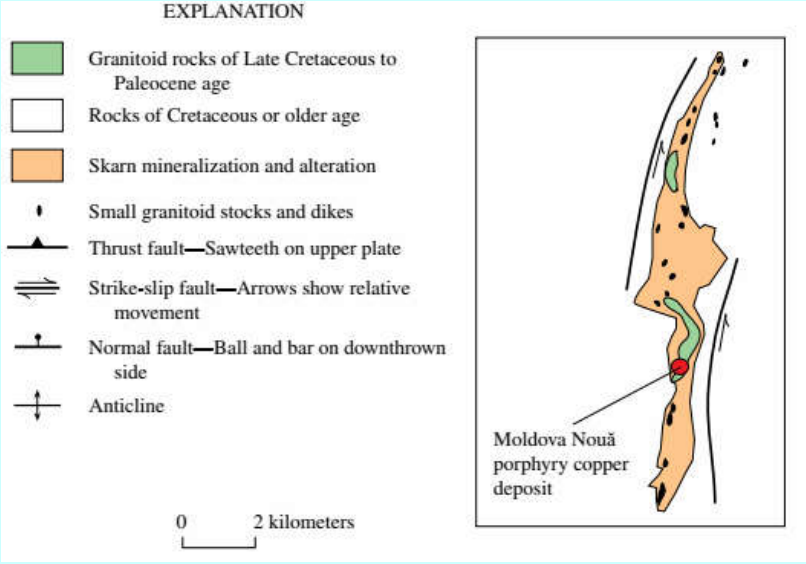
Geodynamic constraints



Sketch map of banatites from the Timok - Srednogorie area, modified in Drew (2006) after Antonijević et al. (1974).



Sketch map of the relationship between Cu porphyry deposits and strike-slip duplex faults in the Srednogorie region, Bulgaria (Drew, 2006).



Interpretation of the senester extensional duplex from Moldova Nouă (Drew, 2006).

If we analyze only a few situations from Banat (Romania), from Timok (Serbia), or from Srednogorie (Bulgaria) we can reach the following conclusions:

Conclusions

- the Gosau-type basins and also the magmatites have a discontinuous, non-uniform character and structurally are controlled by strike-slip fractures in transtensive-transpressive regime, characteristic of an extensional tectonics;
- these types of fractures followed, or not, the path of meso-Cretaceous dislocations; on the other hand, the banatites in the Apuseni Mts., but also in Banat, often seal or cross the contacts between the mezzo-Cretaceous tectonic units;
- both intrusive and extrusive magmatites have a large compositional variety that does not constitute the chemical polarities in relation to a hypothetical axis of a hypothetical arc as in the case of magmatic provinces related to subduction zones;
- in the same sense, there are no age polarities in relation to the same presumed geometry;
- the magmatism, taking into account the volumes involved, the area of distribution and that in general, on a continental scale, the evolutions of banatites from generation to emplacement were extremely short, has a strong extensional signature of a post-collision, anorogenic magmatism;
- the metallogenesis associated with this magmatism is represented by metalliferous accumulations of Fe, Cu, Pb, Zn, with Au, Ag and W, Mo, B, Mg, Te, Bi, Sb, with a great typological variety, spatially controlled by the same type of fractures. It is evident that the transpressive-transtensive regime worked throughout the entire range of magmatic and metallogenetic activity, controlling it. In Banat region, as well as in the Apuseni Mountains, the end of the magmatic activity ceases with mineralizing and/or bearing mineralization lamprophyres. Being so, probably the lamprophyres attend or announce the metallogenetic event.

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Acknowledgments

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