THE PRECAMBRIAN AND PALEOZOIC FORMATIONS OF THE APUSENI MOUNTAINS FROM THE TERRITORY OF ALBA COUNTY

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ABSTRACT: *Regarding the geology of the Apuseni Mountains, it is especially known that they are formed from sedimentary rocks, especially Jurassic and Cretaceous limestones, in which numerous caves were formed. The geological formations in the Apuseni Mountains are much more complex, comprising very old, Precambrian rocks, over 1 billion years old, represented by crystalline schists and igneous rocks. They are mainly present in the central area of the Apuseni, some of them also being present in the north-western area of Alba County.*

In this paper we give a more detailed presentation of these formations, because they have a special economic and touristic importance, many climatic resorts and numerous rural guesthouses have appeared in the area, which attract more and more tourists from the country and from abroad.

Keywords: *crystalline series; petrographic constitution; minerals; magmatic intrusions; absolute age analyzes; palynological; sporo-pollen studies; metallogenesis;*

1. Precambrian and Palaeozoic metamorphic formations

The crystalline bedrock of the Apuseni Mountains is present in the northern part, forming the Gilău-Muntele Mare massif, the north-western part of the Vlădeasa Mountains and the south-eastern part of the Pădurea Craiului Mountains and the southern part of the Bihor Mountains. For Alba county, the area of interest is represented by the crystallophylian formations of the Bihor Mountains and those of the southern Gilău-Muntele Mare massif (fig. 1).

The subdivision of the crystalline basement was made on the basis of the degree of metamorphism and lithological consistency, separating a number of quite well-defined crystalline series, whose age is specified by the use of geochronological (especially absolute K-Ar spills) and sporo-palynological determination

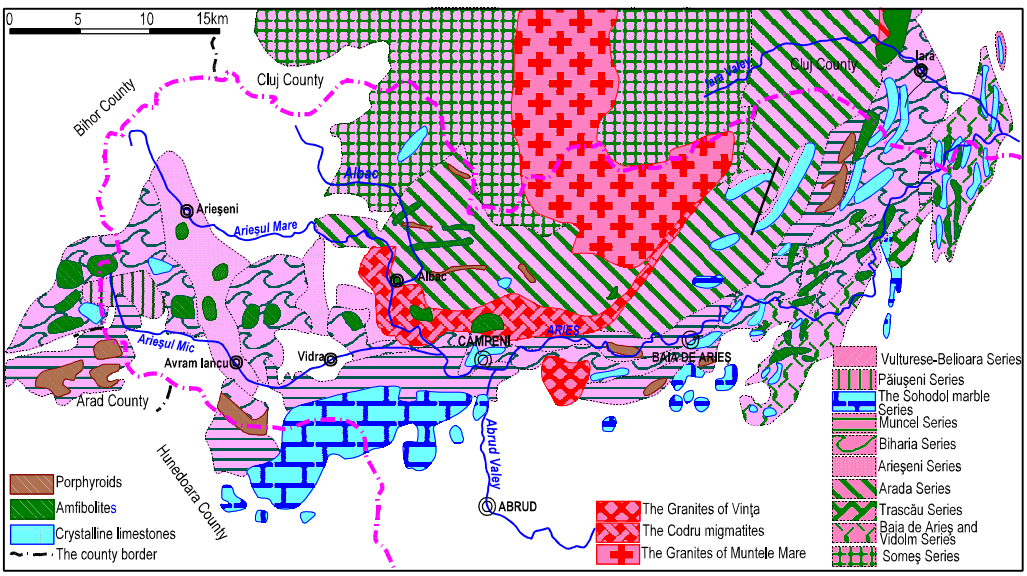

Fig. 1. The Precambrian and Paleozoic formations of the Apuseni Mountains

methods. Alpine tectonics has defined the present structure of the Apuseni, in which the crystalline series constitute the Bihor Autochthon, over which shifts have poured the Codru Sands System and the Biharia Sands System, in which certain facies of metamorphic formations occur.

The formations of the Bihor Mountains and the Gilău-Muntele Mare massif belong entirely to the pre-Hercynian crystalline, which form well-defined units: Someş, Arada, Biharia, Muncel, Mădrizeşti-Baia de Arieş-Vidolm- Lunca and Trascău series, which are occasionally pierced by pre-Hercynian intrusions.

The Someş Series occupies the deepest geometric position in the entire crystalline massif of the Gilău, representing one of its oldest stratigraphic terms and constituting the foundation of the alpine unit of the Bihor autochthon. The series outcrops over a very large area in the Northern Apuseni, its delimitation having been made in 1957 by M. Bleahu and R. Dimitrescu. The series has been divided into three complexes:

1) The lower complex, paragnaisic, consisting of two-mica, frequently granitic paragnaisses, with rare intercalations of amphibole paragnaisses, micaschists and quartzite schists (fig. 2);

garnet-bearing, with intercalations of tourmaline-garnet micaschists and staurolite-garnet micaschists.

The degree of metamorphism of the Someş Series in this region corresponds to the almandine and staurolite zones. To the west of the granitic massif of Muntele Mare, the series preserves its characteristics, so that to the west of the Horea commune, micaschists with garnet, rare amphibolites and a lenticular gneiss occur.

The age of the sedimentary formations from which the Someş Series formed is a relatively deep Precambrian age, the age of metamorphism being definitely Prehercynian. A global rock determination by the K-Ar method gave an age of 381 million years, and two pegmatite muscovite samples gave an age of 488 million years, placing the metamorphic process in the second half of the Caledonian (Ordovician-Silurian) cycle.

The Vdolm-Lunca Series forms the largest part of the Trascău island crystalline, the entire north sector of the Arieş river, and the western half of the sector south of this river, together with the smaller islands of Valea Ascunsă and Onceşti, constituting a mesometamorphic series. Its petrographic composition includes: quartzite schists with chlorite and garnet, quartzite schists

Fig. 2. Paragneiss bodies in the upper basin of the Iara valley

2) The medium complex, quartzite, of lesser thickness, composed of micaceous quartzite schists, sometimes granitic, with rare intercalations of quartz-amphibole schists;

3) The upper complex, consisting mainly of micaschists with muscovite and biotite, often

with muscovite, chlorite and garnet, micaceous quartzite schists (with two micas) with garnet and quartzites with biotite. To the west of Vidolm is a zone of more pronounced metamorphism, in which micaceous mica schists and paragnaisses, frequently garnet-bearing, occur, with thin

intercalations of nodular gneisses with potassic feldspar and garnet. Note the presence of numerous intercalations of amphibolite and crystalline limestones.

Petrographic features indicate that the Vidolm-Lunca Series has been metamorphosed into the amphibolite facies, with a zone of almandine and a zone of staurolite and disten.

Formations of the Vidolm-Lunca series are attributed to the Upper Anteterozoic age.

The Baia de Arieş Series forms the southeastern extremity of the Gilău-Muntele Mare massif and consists of a mesometamorphic series, forming the entire crystalline spur of Baia de Arieş, which separates the Abrud basin from the Sălciua corridor. North of Arieş, the same series extends to a tectonic line from the Dealul Cărbunarilor (NE of Lupşa) to the east and then northeast, disappearing under sedimentary formations west of the village of Runc. The series is part of an upper mantle, its bedrock is nowhere exposed by erosion, and lies anomalously over the Biharia and Muncel Series.

The main petrographic features of the Baia de Arieş series are given by the predominance of garnet-bearing phyllites and garnet-bearing micaceous quartzite schists with interbedded biotite garnet-bearing paragnaisses, plagioclase amphibolites and crystalline limestones. To the north, in the Orăşti-Poşaga-Runc region, paragnaise, sericitic or graphitic quartzites, crystalline limestones, amphibolite schists and ortho- amphibolites occur in the mass of micaschists and sericite schists with garnet and almandine (fig. 3).

The age of the formations constituting the Baia de Arieş series is Lower Proterozoic (Middle Precambrian), according to sporo-pollen studies carried out on micaceous garnet schists in the Arieş Valley, the forms identified being: *Fibularix sp., F. cf. porulosa, Scintilta sp., Sc. cf. perforata, Millaria implexa, Catinella polymorpha, Leiosphaeridium sp.*

The Trascău Series forms the southeastern sector of the crystalline island of Trascău, along with the smaller occurrences that mark, to the south, the zone of the Bedeleu-Râmeţi ridge, constituting a crystalline series with epimetamorphic characters, its main mass being composed of sericite-chlorite schists with subordinate intercalations of white quartzite, black graphitic quartzite and crystalline limestones. The metamorphic grade of the series corresponds to the green shale facies, chlorite zone (fig. 4).

According to the geological map sc. 1:200 000, the series is attributed to the Upper Proterozoic-Paleozoic.

The Arada Series covers the Someş Series in the Horea-Albac area, is epimetamorphic in character and has a thickness of about 4 500 m and extends eastwards to the north of Lupşa (fig. 1), which M. Bleahu and R. Dimitrescu delineated and described as the Arada Series.

It is mostly composed of sericite- chlorite and

3. The Şipote waterfall on the Aries valley, in the Baia de Aries series

Fig. 4. The green shale facies in Trascău Series

sericite-quartzite shales with frequent intercalations of sericite-chlorite shales with albite and amphibole shales. Porphyroid bodies derived from granitic magmas occur in their mass.

The basal part of the Arada series, in the immediate vicinity of Horea, consists of sericite-quartzite and chlorite schists with biotite that appears as an intercalation that can be traced from north of Scărişoara to the southern slope of the Muntele Mare massif.

The terminal (southern) part of the Arada Series is also characterized by more intense metamorphism, east of Albac being bounded by a continuous mica schist bank with muscovite and porphyroblasts of chloritized garnets.

Sporo-pollen determinations demonstrated the late Precambrian to lower Cambrian age of the Arada Series, the identified forms being: *Laminarites, Leiosphaeridium sp., Protosphaeridium sp., Pr. flexuosum, Pr. acis, Pr. cf. densum, Favosphaeridium sp., Stictosphaeridium cf. sinapticuliferum, Asperatopsophosphaera sp., Protomyciero-sphaeridium marmoratum*.

The Arieşeni Series, so called by C. Ionescu (1962), a term also used in later works, consists of a succession of metapelitic rocks, with quite rare metapsammitic intercalations, their predominant colour being greyish-green, with a satiny lustre, due to the presence of sericite together with chlorite. On the cleavage planes, green shales are insinuated in 10-50 cm thick beds. The monotony of the petrographic constitution of the series is interrupted by a horizon-reperture of shaly green cement conglomerates with quartz buckets 2-30 cm in diameter.

This bench, several tens of meters thick, is interbedded in the middle part of the Arieşeni Series, and in its vicinity the presence of green quartzite sandstones is frequently noticed.

In the Arieşul Mic basin, the green shales of the Arieşeni series are crossed by a fairly large number of dykes and porphyritic diabase sills several kilometres long (fig. 5).

The bedrock of the Arieşeni Series consists of sericite schists with some metaconglomerats interlayers occurring in a thin band south of Gârda.

Palynological determinations show *Zonotriletes anomalus, Z. pseudohirsutus and Z. incisofrilobus* forms in the green shales, indicating the Lower Carboniferous age. The same age is also indicated by the forms determined in the rest of the series: *Leiotriletes sp., L. ornatus, Calamospora sp., Verruco-sisporites rariverrucosus n. sp., Microreticu-latisporites sp., Reticulatisporites planus, Densosporites cf. variomarginata, Triquitrites sp., Tripartites sp., Simozonotriletes sp., Knoxisporites sp.*

Fig. 5. The green shales of the Arieşeni series on the way of Avram Iancu

In conclusion, the Arieşeni series represents an upper term of the Hercynian crystalline, developed in a characteristic facies, being equivalent to the youngest formations of the upper complex of the Păiuşeni Series.

The Biharia Series was identified by P. Roziozsnik and M. Pălfy in the region of Biharia Peak, where they describe albite gneisses with chlorite or amphibole, amphibole schists, ortho-amphibolites, epidotites and crystalline dolomites. D. Giuşcă published in 1937 a more detailed geological map of the same region in which he specifies the position of the Biharia series, which includes chlorite gneisses and schists with albite porphyroblasts, ortho-amphibolites and rare dolomites.

Later (1957), M. Bleahu and R. Dimitrescu traced the development of the series outside the previously known areas, establishing that the Biharia Series constitutes a continuous zone, generally oriented east-west, which passes through the Belescilor hill, Vadu Moţilor commune, Boteşti village, tapers almost completely north of Bistra and is then found between Bistra and Lupşa, north of Arieş, following the north-east direction north of Valea Lupşii.

The main bedrock of the Biharia series, at least 1200 m thick, consists of chlorite schists with albite porphyroblasts alternating with other green schists with chlorite, epidote and calcite, with actinite, epidote and albite and with albite gneisses with muscovite and chlorite. Very characteristic for the upper half of the series is an intercalation of crystalline dolomitic limestones, of variable thickness, found from below the Bihariei peak to the eastern part of the Gilău Massif.

At the Arieş springs, D. Giuşcă (1960) identified a body of ultrabazites metamorphosed into magnesian schists (serpentinites, talcose or actinolitic schists), with magnetite impregnations. Ultrabazites are intruded in dolomitic limestones, and diopside, garnet, epidote and actinide skarns have developed in contact with them.

In the Biharia Massif, the series shows the following stratigraphic subdivision:

- a lower complex, consisting of albite schists with chlorite and muscovite, in which, subordinate to this, interlayers of chlorite schists with albite and muscovite schists occur;
- a second complex, consisting of chlorite schists with porphyroblasts of albite;
- a third complex, consisting of albite schists interbedded with thin layers of feldspathic quartzite and chlorite schists with albite porphyroblasts;
- the fourth complex, consisting mainly of chlorite schists with albite interbedded with albite gneisses, dolomitic limestones and chlorite schists with calcite.

The degree of metamorphism of the Biharia series generally does not exceed the chlorite zone, except for the Biharia Massif, where garnet and biotite appear intensely chlorinated, indicating a metamorphic facies corresponding to that of epidote and albite amphibolites.

The base of the Biharia series is crossed by

intrusions of granitoids belonging to the Codru migmatitic series.

Spore and pollen determinations revealed the following forms: *Protosphaeridium sp., Pr. flexuosum, Pr. asaphum, Pr. cf. Ensum, Kildinella sp., Pseudozonosphaerites sp., Ps. cf. populosum, Oilygmatosphaeridium cf. semireticulatum, Turuchanica sp., Leiosphaeridia bituminosa and Laminarites*, indicating Upper Precambrian age.

The Muncel Series was first separated in 1935 by P. Rozlozsnik, including sericite, quartzite and graphitic phyllite as sedimentogenic terms, and porphyry and ocular gneiss as orthorhombs. The latter are considered as metamorphic products of granites or granitic porphyries. At the sources of the Arieşul Mic valley, the series crystalline is sherd over Carboniferous. According to D. Giuşcă, who published the first detailed geological map of the same region (1937), the phylites with interlayers of porphyroids and epigranites cover a level of shales with bleached porphyroblasts. The assemblage overlies the Carboniferous in the region of the Muncel, Romăna, Dalea, Runc and Vârful Plaiului.

The term "Muncel Series" was introduced by M. Bleahu and R. Dimitrescu in 1957. The eastern development of this series runs along the Arieşul Mic valley as far as Câmpeni and along the Arieş between Bistra and Lupşa. A second continuous strip runs further north between Certeje and Valea Lupşii. Everywhere else, the Muncel Series normally covers the Biharia Series.

The main petrographic constituents, as described by R. Dimitreseu (1958), are represented by quartzite-sericite and muscovite-chloritic shales, sometimes alternating with shales with albite, chlorite and epidote. As intergrowths, graphitic, porphyritic quartzites and an ocular gneiss occur at Mihoeşti, at the contfluence of the two Arieş. The upper term of the series consists of chlorite-sericite schists with biotite.

A more detailed stratigraphic subdivision of the Muncel Series was made by R. Dimitrescu (1972), who separates three horizons:

- **The lower horizon,** normally covering the Biharia Series between Avram Iancu and Lupşa, consisting of sericite-chlorite schists alternating with sericite schists with albite, as well as chlorite schists with rare intercalations of albite gneisses and porphyroids. The sporo-pollen inventory indicates the presence of species: *Protosphaeridium sp., Pr. acis, Pr. tuberculiferum, Pr. cf. patelliforme, Kildinella cf. hyperboreica, Zonosphaeridium disterminum, Favosphaeridium sp., Protomycterosphaeridium marmoratum, Asperatopsophosphaera sp. , Archaeopsopho-sphaera cf. asperata*, indicating Lower Cambrian age.

- **The middle horizon,** represented by sericite schists, with interbedding of metariolitic porphyroids and ocular gneisses, follows the Arieşul Mic between Avram Iancu and Câmpeni and is found to the east between Bistra and Lupşa. In this middle horizon of the Muncel Series a sporo-pollenic content could be identified, placing it in the Middle Cambrian.

- **The upper horizon** starts with a very constant level of graphitic quartzites, which can be traced on the southern slope of the Arieşul Mic between Avram Iancu and Gura Sohodolului and is found between Bistra and Valea Lupşii, as well as on the Valea Lungă, north of Baia de Arieş. West of Câmpeni and north of Baia de Arieş, the black quartzite layer is covered by the transgressive marble Series. Between Bistra and Valea Lupşii, above the black quartzites, there are sericite schists with biotite, with inter-bedded fine biotite paragnaise, amphibole schists and metariolitic porphyroids with biotite.

On black quartzites and biotitic schists from the Arieş Valley (Gura Sohodolului) and from the Caselor Valley (Lupşa) the following microfloristic content was determined: *Leiosphaeidium sp., Synsphaeridium sp., Syns. conglutinatum, Tasmanites sp., T. cf. mangaseus, Protoleiosphaeris dium cf. flavum, Favosphaeidium sp., Archaeohystricho-sphaeridium sp.*, which certainly indicates the Cambrian age, and may also pass into the Ordovician.

The total thickness of the Muncel Series is between 1000 and 1500 m.

The Sohodol Marble Series was first identified by M. I1ie (1936) in the crystalline island of Trascăului (fig.), where the author describes crystalline limestones occupying the axes of three synclines: Băieşilor hill - Cosaşului peak, Trascăului-Fudoaia hill and Iarul-Cornu peak, the crystalline limestones extending in a single plug to the west of Văliişoara, the superior stratigraphic position of the limestones in relation to the other crystalline schists being mentioned.

In the crystalline spur of Baia de Arieş, the discordant position of these marbles, 200-300 m thick, over the crystalline schists of the Baia de Arieş Series and over the granitoids of Vinţa is noted. North of Baia de Arieş, between the Cărbunarilor peak and Valea Lungă, the same marbles are found covering the graphitic quartzites of the Muncel Series and supporting the upper mantle of Baia de Arieş. The imposing mass of marbles is formed by crystalline macrogranular limestones extending from Sohodol to Avram Iancu (fig. 6).

Fig. 6. Marble quarry from Sohodol

Dominating the southern slope of the Arieşul Mic valley, the marbles constantly cover a sheet of black quartzites and graphitic schists, forming the upper horizon of the Muncel Series. Palynological analyses carried out on samples from Cîmpeni indicate Upper Cambrian to Ordovician age.

The marbles are transgressively disposed over the Baia de Arieş, Vidolm-Lunca, Muncel and Trascău Series and over the Vinţa granites and have undergone a rather intense metamorphism, probably mesozonal, towards the east its intensity decreasing steeply. At times, the marbles show a schistosity that is probably due to Hercynian orogeny.

The Păiuşeni Series develops characteristically in the Zarand Mountains, extending to the southern part of the Bihor Mountains (fig. 1), in the area of the Arieşul Mic valley springs, being described for the first time by H. Savu (1962) as consisting of three crystalline schist complexes.

The Metamorphosed Grezo- conglomeratic Complex is 2000-2500 m thick, consisting mainly of quartzites and metaconglomerates, alternating with phyllite and crystalline limestones. The Metamorphosed Grepsiferous- conglome-ratic Complex of the Păiuşeni Series is thought to belong mostly to the Lower Devonian, but spore determinations do not rule out that the base may also include part of the Upper Silurian.

The Metamorphosed Ophiolitic Complex belongs to the Middle Devonian and consists mainly of tuffaceous, metabasalt and metadolerite schists, interbedded with small bodies of metagabbroids, metagabrodiorites and metadiorites, associated with acidic and porphyroid metatuff, sometimes with interlayers of quartzite, jaspilite and phyllite. The metamorphosed basic rocks of this complex, namely quartz porphyries, represent the initial magmatism of the Hercynian cycle. The complex is over 700 m thick.

The Upper-phyllite Complex of the Păiuşeni sandstone consists mostly of phyllitic rocks, including sericite (muscovite) and chlorite phyllites, sometimes carbonaceous phyllites, chlorite schists and sericite schists. Interspersed between these are numerous layers of quartzite and less frequently metaconglomerates similar to those described in the lower complex. Interlayers of basic metamorphosed rocks and

metakeratophyres also occur.

The degree of metamorphism of the Păiuşeni Series is generally low and remains approximately at the level of the green shale facies. The distention present in the constitution of the series rocks was formed due to the special chemical composition of their Al2O3-rich rocks, this mineral having very wide stability limits.

Palynological forms that have been determined in the formations of the Păiuşeni Series in the southern part of the Bihor Mountains: *Leiotriletes sp., Calamospora microrugosa Ibr., Verrucosisporites sp., Granulatisporites microgranifer Ibr., Reticulatisporites sp., Triquitrites sp., Triquitrites cf. trivalvis Waltz, Desmosporites sp., Euryzonotriletes sp., Tetraporina sp.*, indicate for the upper complex of the Păiuşeni Series the Upper Devonian - Lower Carboniferous age.

The Vulturese-Belioara Series occurs in the Runc valley, downstream of Lunca Largă, on both sides of the Poşaga valley, downstream of Belioara, in the Bujoi hill, in the valley of Sălciuţii, forming the Scărişoara-Belioara limestone massif and in the Leurda-Misărniţa hill, in a horizon of about 50 m thickness, consisting of metamorphosed conglomerates and sericitic quartzites, with rare sericitic schist interbeds. The colour of the blastopsephitic and blastopsammitic rocks is generally white, the appearance of the latter being saccharine. In the Lunca Larga, Scarişoara-Belioara area the metaconglomerate1or cement sometimes takes on a pinkish or purplish hue.

The second term of the Vulturese-Belioara Series consists of a horizon, sometimes discontinuous, of microgritty dolomites, occurring in the Runc gorges, along the Vulturese-Bujor ridge, in the Scărişoara-Belioara ridge and in the Leurda-Leaşu ridge, where two varieties have been described: graphitic, blackish dolomites, stratified in 0.5-2 m beds, and ankerite dolomites (parankerites), yellowish-pink or even purplish, lacking stratification.

The third term of the Series consists of white or less frequently pink marbles, with a larger grain size than dolomites and stratified in slabs or banks up to 2-3 m thick, constituting the Vulturese (Cheile Runcului-Valea Sălciuţii) and Scărişoara-Belioara limestone massifs. The three limestone-dolomitic massifs, Vulturese, Scărişoara-Belioara and Leaşu-Leurda, represent only three compartments of the same alignment, separated by two north-south oriented faults.

In the southern part of the Vulturese ridge, above the marble horizon, graphitic dolomites reappear, covered in turn by quartzites, while the rest of the mantle is covered directly by sericite schists with black quartzite interbeds, porphyroids or sericite schists with garnets.

There has been much discussion and controversy about the age of the series, with the basal horizon being mostly thought to be of lower Permo-Triassic age and the dolomites of middle Triassic age.

2. Hercynian magmatic formations

The Hercynian Orogeny was also characterized by intense magmatic activity, especially during the early Cambrian phase of orogeny. The magmatic intrusions that took place during this period are mainly of a granite, granodiorite and diorite nature, but also of basic chemistry (metagabbro, metadiorite, orthoamphibolite).

The Granites of Muntele Mare represent the largest magmatic intrusion in the Apuseni Mountains crystalline, the north-south direction measuring about 35 km and the south, east-west oriented part not exceeding 14 km. The maximum width of the massif is 10 km (fig. 7).

The outer boundary of the massif with the crystalline schists it crosses is everywhere sharp. On the other hand, in the interior of the body, and especially in its southern part, there are numerous shale interbeds, with VSV-ENE direction.

The mineralogical composition of the massif is quite uniform: quartz, microcline- microperlite, albiclase (10-20% An), myrmekit, biotite, muscovite. Chemical analyses give values corresponding to granitic and leucogranitic magmatic groups.

Texturally, the main variety of granite is porphyroid, with megacrystals of potassium feldspar that can reach up to 4-5 cm. Microscopic studies indicate that the bedrock represents the consolidation product of a granodioritic magma and that the microcline megacrysts were formed by metasomatosis subsequent to consolidation. Other varieties detected are microgranular granite, which occurs quite rarely, pegmatoid granite occurring more frequently in the northern part of the massif, and gneissic granite, which overlaps in places all the other varieties, representing in fact

Fig. 7. The peak Pietrele Mărunte and the reserve Scăriţa-Belioara from Muntele Mare

a marginal facies. From a mineralogical point of view, the accidental presence of tourmaline and garnet in the granite, together with ovoid xenoliths of quartz-dioritic composition, can be mentioned.

The granite of Muntele Mare crosses, for the most part, the Someş Series, its southern extremity being in contact with the Arada Series.

Regarding the age of the formation, the first series of determinations by the K-Ar method gave a single value of 530 million years on total rock (V. Ianovici et al., 1969). Another series of determinations on muscovite, biotite and potassic feldspars did not find this high value, obtaining ages between 232 and 89 million years.The lower values are due to Cretaceous shifts and banatitic intrusions, which affected the granitic pluton. Due to the fact that the granite cuts through the Arada Series, whose age goes up at least to the Lower Cambrian, the highest values obtained can be considered as indicating the maximum age of the intrusion.

The Codru Migmatites are in the form of an intrusion that pierces the formations of the Păiuşeni Series. The first detailed petrographic and petrochemical description of these formations is due to M. Palf y and P. Rozlozsnik (1939), who note the presence of magmatic intrusions and metamorphic rocks forming almost the entire crystalline bedrock of the Codru Mountains.

This series traced cartographically between Gârda and Lupşa (fig. 1), has an obvious migmatic character, with two distinct phases of intrusions: the first is basic in nature (metagabbroids and melanocratic metadiorites - orthoamphi-bolites), the second is acidic and intermediate (granites, plagioclase granites, granodiorites and quartz diorites).

The Series is occasionally traversed by small pegmatitic (granitic, less frequently dioritic), typically synorogenic, phyllos.

Determinations of isotopic ages by the K-Ar method gave a value of 524 million years for muscovites from pegmatites, as well as a value of 344 million years. Another series of 14 determinations, carried out on muscovite, biotite and hornblende from various rocks of the Codru Series, only obtained values between 343 and 158 million years.

In conclusion, the age of the formations is accepted as the lower Cambrian, affected by a Hercynian rejuvenation, highlighted by the second series of determinations, which places them in the upper Devonian.

As a structural position, the Codru migmatic series is found in the Bihor and Muntele Mare mountains, at the base of the Codru alpine cloth system (Finiş-Gârda unit). At Gârda-Ocol, on Arieşul Mare valley, at the base of the Arieseni sheet, intrusions of the Codru granitoids have been reported crossing sericitic schists of the the Păiuşeni series.

The Granites of Vinţa. The crystalline shales

of the Baia de Arieş Series are crossed, south of the locality, by a massif of granites of about 3 km in diameter, called Vinţa granites, after the name of the village around which they outcrop.

The shape of this massif is quite irregular, the limits being accompanied by a rather thin zone of injection and migmatization.

Along with the massive granular rocks, shale (gneiss) varieties can be distinguished, which represent the most widespread rocks, varieties with microcline porphyroblasts, pegmatoid varieties, as well as veins of pegmatites that cross both the massif and the surrounding crystalline schists. A migmatic origin is generally accepted for the entire massif.

The absolute age analyzes by the K-Ar method indicated a value of 508 million years for the muscovite from a pegmatite of the Vinţa massif, which places the formations in the Upper Cambrian, and another, rejuvenated value of 172 million years.

3. Metallogenesis associated with Hercynian magmatism

The metallogenetic province of the Apuseni Mountains is individualized as an Alpine-Carpathian type unit, with specific characters, but also with common characters with the other Carpathian units. The province materializes as a subduction unit with concentrations of mineral substances associated with the prealpine crystalline formations, regenerated in the Alpine Orogeny, alongside the metallogenesis associated with Hercynian and Alpine magmatism (Gh. C. Popescu, 2009).

In the subprovince associated with the Hercynian magmatism, also known as the North Apuseni Subprovince, four metallogenetic districts were separated, on the territory of Alba county there is only one district (fig. 8).

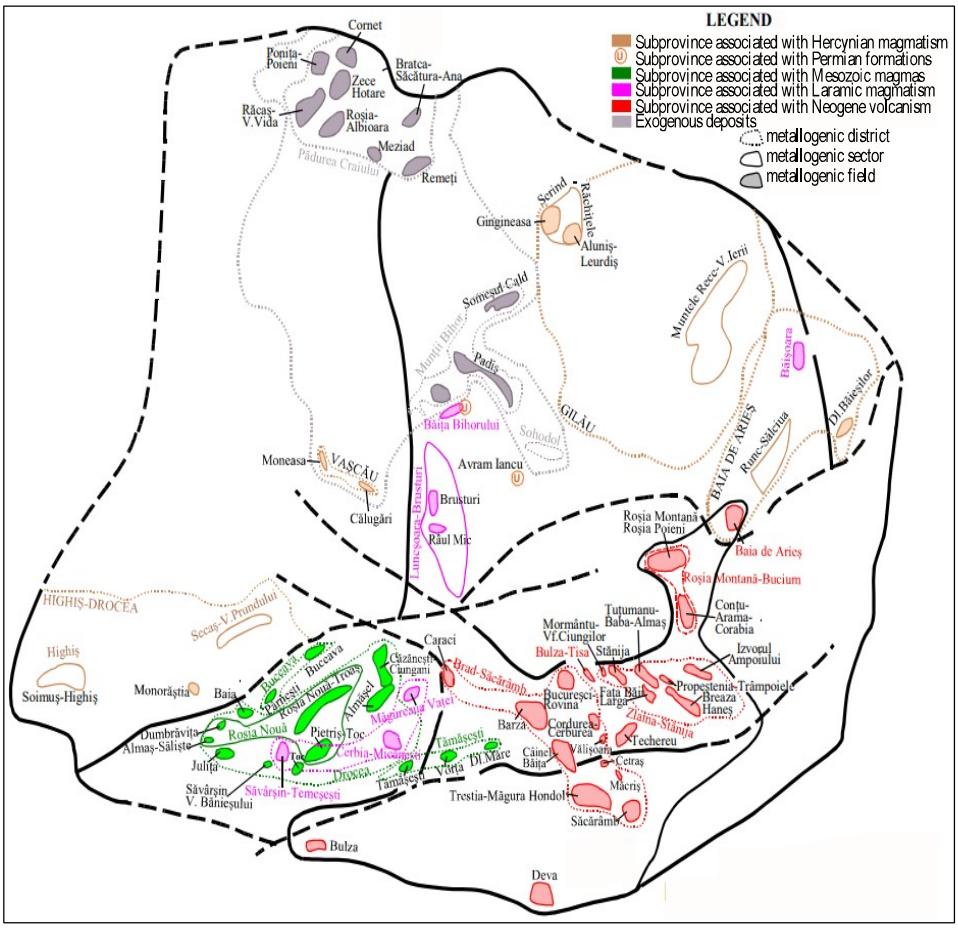

Fig. 8. Apuseni Mountains - metallogenic map

The metallogenetic district associated with the mesometamorphic crystalline shales of Baia de Arieş. Within this district, mainly at the level of crystalline limestones and amphibolites, accumulations of metamorphic iron and manganese ore are located, originating from the initial volcanogenic- sedimentary accumulations. Following the fragmentations of the Alpine Orogeny, two metallogenetic units of lower rank were built, respectively a sector and a metallogenetic field.

- The metallogenetic sector with carbonates and silicates of iron and manganese Runc-Sălciua which includes ore bodies arranged on two alignments.

The western alignment cantons the springs from Runc and Dealul Bujorului, which were, in the past, the object of exploration works. The mineralization is located at the limit between the schists and the crystalline limestones, with the appearance of a concordant vein with a length of 200 m and a vertical extension of up to 700 m, the thickness being 30-120 cm. The ore is made up of hematite with around Fe content.

The eastern alignment extends from the V. Sălciuţa basin and Culmea Doboş to the south, where there are several ore springs in the Cioara area, which represent iron caps of some lenticular and stratiform accumulations, with thicknesses up to 2.5 m. The ore is manganese and includes pyrolusite, braunite, husmanite, magnetite and iron hydroxides.

In the western part of the sector, on V. Poşaga valley, springs of polymetallic sulphides, mainly pyrite, were reported.

- The field with accumulations of iron and manganese Dealul Băieşilor includes iron ore springs 2 km NW of the town of Remetea (Pârâul Fierului, dealul Băeşilor, Buha, Colţanele), known since the 13th century.

The mineralizations appear in layers with thicknesses of up to 1,5 m and with extensions up to 1200 m, being formed of siderose and hydroxides of iron and manganese. As isolated springs, is mentioned the existence of a vein with pyrrhotite, known for about 2 km NW of the Buru village.

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