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PRECAMBRIAN FORMATIONS IN THE SOUTHERN CARPATHIANS IN ALBA COUNTY

Prof.PhD. NICOLAE LUDUŞAN, prof.PhD. LEVENTE DIMEN
"1 December 1918 University" of Alba Iulia, Romania

ABSTRACT: *The portion of the Southern Carpathians, namely the Şurianu Mountains, located in Alba County, is of particular importance from a geological, economic, and tourist point of view. This paper presents the main geological characteristics of this mountain range. The crystalline schists, which form the main mass of the massif, were formed by the metamorphosis of sedimentary deposits in the Pre-Baikal tectonic cycles, in the Eo- and Mesoproterozoic. The degree of metamorphism varies from mesometamorphites to epimetamorphites, grouped into four petrographic complexes. The schist mass contains significant accumulations of useful mineral substances, both metallic and non-metallic (Au, Zr, Mn, Fe, Al, gypsum, graphite, etc.), some of which are exploited or exploitable.*

Key words: *mountain massif; petrographic constitution; rystalline schists;minerals?metallographic units;useful mineral substances.*

Geological features of the Şurianu Mountains

The Southern Carpathians constitute a unit of the Carpathian Orogen that is distinct from a tectogenetic point of view. The convergence process has brought them to their current structure, giving them the specificity of a complex orogenic edifice (Gh.C. Popescu, 2009).

The Southern Carpathians are represented in Alba County mainly by the Şurianu Mountains and, to a lesser extent, by the Cindrel Mountains (fig.1). The Cindrel Mountains, or Cibin Mountains, form the left bank of the Sebeş River, and the Şurianu Mountains, or Sebeş Mountains, occupy the entire southern part of the county, west of the Sebeş River. The two mountain ranges form a homogeneous massif, both morphologically and petrographically, the entire area consisting of crystalline schists.
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In the current structure of the Southern Carpathians, three major geostructural units can be distinguished: ***Danubian Autochthon, Getic Nappe,*** and ***Supragetic Units***. In this context, the crystalline formations of the area located in Alba County belong to the Getic Nappe.

The Getic Nappe covers most of the Southern Carpathians, being delimited by the Olt Valley to the east and the Danube to the west.

Its area of distribution includes the following mountain ranges: the Făgăra Mountains, the Căpăţânei Mountains, the Cindrel Mountains, the Şurianu Mountains, the Poiana Ruscă Mountains, the Semenic Mountains, and the Banat Mountains with the Locvei Mountains, the Dognecea Mountains, as well as the Buziaş massif. The Godeanu Mountains and the Bahna and Porţile de Fier areas of the Mehedinţi Plateau also belong to the Getic Belt.

The Getic Nappe is composed of crystalline formations and associated granitoids, which make up the pre-Alpine crystalline massifs, and sedimentary formations that form the sedimentary cover. These crystalline schists were formed during the pre-Hercynian orogenies and belong to the *mesometamorphic* and *epimetamorphic* groups (fig. 1).

The crystalline schists that show advanced metamorphism, of the mesozone type, are represented by gneisses with potassium feldspar, paragneisses, mica schists, amphibolites, crystalline limestones, etc. These make up what has been described as the **Sebeş-Lotru Series**, which constitutes most of the Făgăraş Mountains, the Lotru-Cindrel-Şurianu Mountains, the southern part of the Poiana Ruscă Mountains, the Semenic Mountains, most of the Buziaş massif, as well as the Godeanu Mountains and the Bahna and Porţile de Fier areas.

In the Şurianu Mountains, there are both ***mesozonal crystalline rocks***, which develop over the largest part of the mountain range, and ***epizonal crystalline schists***, developed in a restricted area occupying the northern and northwestern part of this range.

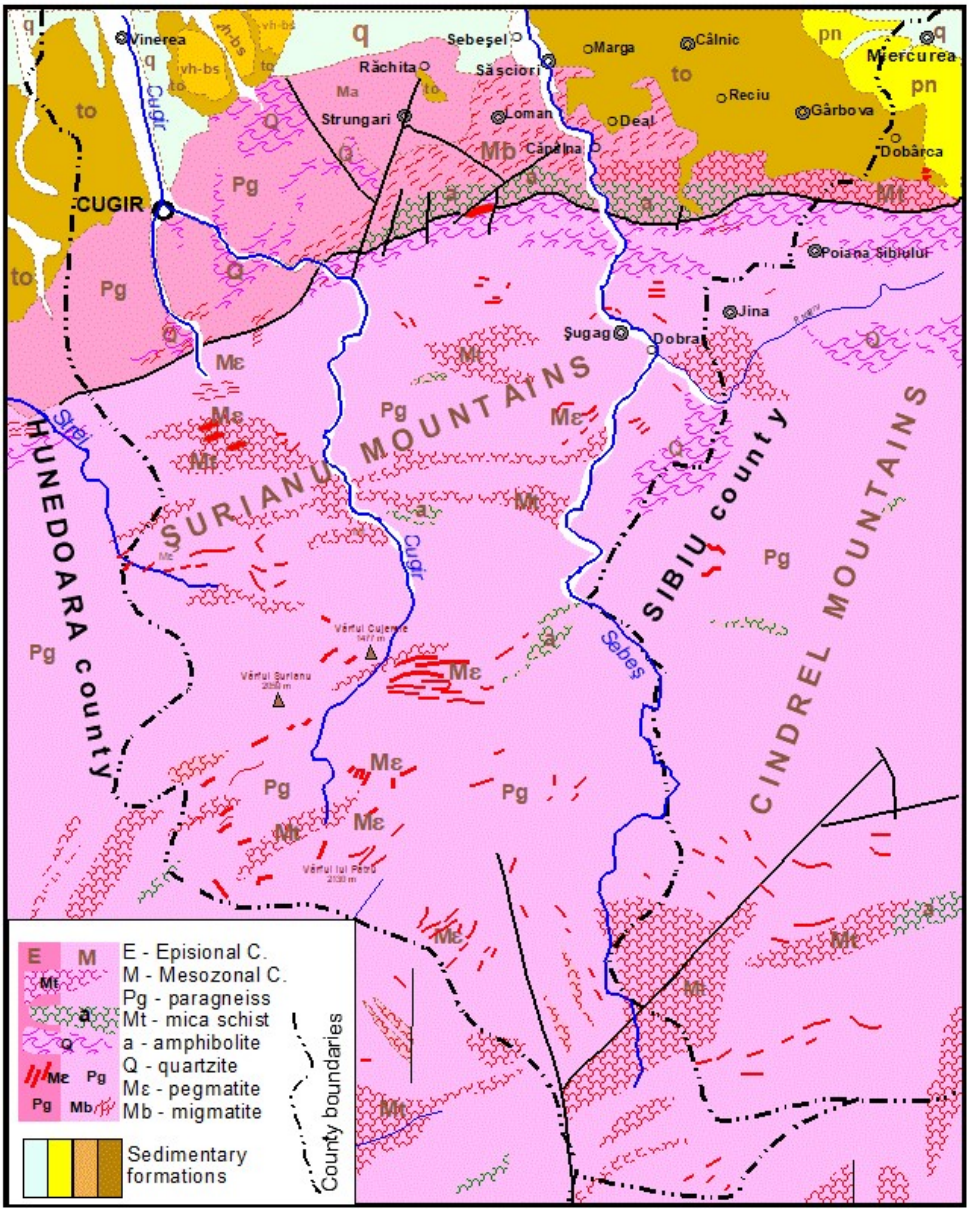

Fig. 1. Geological map of the Şurianu Mountains
(based on: Geological map of Romania, scale 1:200,000, Orăştie sheet)

The mesozonal series was formed by the metamorphosis of a clay-gravel complex, with weak marl intercalations, which gave rise to mica schists, paragneisses, amphibolites, and quartzites. In this complex, there were also some aplite-pegmatite injections that gave rise to various types of gneisses, pegmatites, and aplites.

In the Sebeş-Lotru Crystalline, there are also numerous veins, pockets, or lenses of pegmatites, resulting from metamorphic differentiation processes.

In the **mesometamorphic ensemble** of these mountains, H. Savu distinguished several lithofacial complexes (fig. 2):

- ***the sillimanite gneiss complex,*** which is individualized at the bottom of the crystalline schist stack and consists of different types of gneisses: with *cordierite* and *sillimanite*, muscovitic, biotitic or two-mica gneisses, injection gneisses, lenticular gneisses, ocular gneisses, aplitic gneisses, granitic gneisses, to which are added paragneisses with *biotite* and

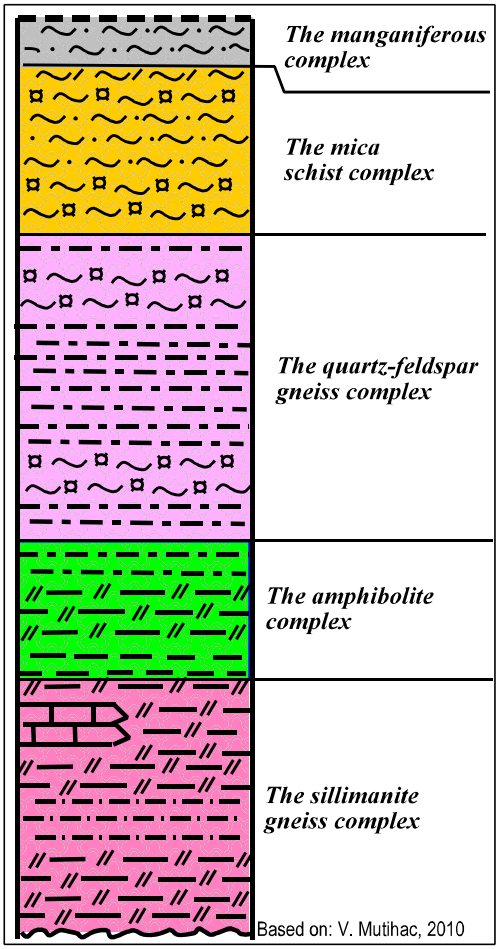

Fig. 2.The stratigraphic column of crystalline schists in the Şurianu Mountains

muscovite, pegmatites, crystalline *quartz* and subordinate amphibolites and migmatitic rocks, which form the eastern part of the Cibin Mountains;

- ***the amphibolite complex*** is represented by alternating amphibolites (with *biotite, epidote, garnets, pyroxenes*) with quartz-feldspar gneisses and biotite paragneisses, present along the Lotru Valley, in the southern part of the Şurianu Mountains, and in the central part of the Cindrel Mountains;

- ***the quartz-feldspar gneiss complex*** includes mica schists with *muscovite* and *biotite* and, to a lesser extent, mica schists with *disthene*, *staurolite, amphibole,* and manganese schists, with the same distribution area as the previous complex;

- ***the mica schist complex*** consists mainly of different varieties of mica schists (with *biotite, garnets, disthene, staurolite*, *with tourmaline, with hornblende*), to which are added biotite quartzites and subordinate amphibolites, the components of this complex being found in the southern part of the Căpăţânii Mountains, in the Cindrel Mountains, in the central part of the Sebeş Mountains and in the Iezer-Păpuşa peak;

- ***the manganiferous complex,*** which ends the Sebeş-Lotru crystaline suite, appears in the middle zone of the Sebeş Mountains and consists of various types of schists with manganese silicates as intercalations in mesozonal crystalline schists, formed from: biotite paragneisses with *garnets*, biotite mica schists with *garnets* or sometimes with *disthene,* associated with biotite quartzites, which occupy a synclinal position in the central part of the Cindrel and Şurianu massifs.

The age of the mesometamorphic crystalline schists of the Getic Nappe can be deduced from their relationship with the overlying epimetamorphic crystalline schists and on the basis of radiometric data; an analysis of *mica* from the Sebeş-Lotru Crystalline indicated 838 Ma. This would suggest that the mesometamorphic rocks in question are is the result of metamorphism that occurred in the early Neoproterozoic, but they could be older. Radiometric data indicate a final rejuvenation, so their age is most likely Eoproterozoic.

Within the Lotru-Cindrel-Şurianu Massif, the **epimetamorphic rocks** occupy the extreme north of the massif, at the contact with the sedimentary rocks of the Transylvanian Depression, in the form of a band that can be traced from the Secaşul Mare Valley to the Orăştie Valley. The epimetamorphic schists that outcrop in the Sebeş Valley basin are represented by amphibolic schists, quartz schists, and chlorite-muscovite schists with magnetite, various varieties of crystalline limestones, and graphitic schists.

The epimetamorphic schists are arranged transgressively and discordantly over the mesometamorphic crystalline schists of the Sebeş -Lotru series.

The age of the epimetamorphic crystalline schists in the Getic Nappe is deduced from their superposition relationships with the Sebeş-Lotru Crystalline, considering that there is a metamorphism discordance between them. In this interpretation, the epimetamorphic crystalline schists would have been generated by a Neoproterozoic metamorphism phase, namely in the Cadomian cycle.

Metallogenesis and mineral resources

The metallogenesis of the Southern Carpathians, which is extensive and of particular importance, was individualized during the convergence process, the subduction stage. Currently, the entire massif forms a distinct metallogenic province with specific characteristics, namely **the Southern Carpathian Metallogenic Province**, which comprises four subprovinces: **the Getic Subprovince, the Danubian Subprovince, the Mehedinţi Plateau Subprovince and the Banatitic Subprovince.**

The formations at the western end of the Getic Subprovince appear in the territory of Alba County, namely those belonging to the Sebeş -Cibin-Lotru District (Fig. 3).

The Sebeş-Cibin-Lotru Metallogenic District is the largest subunit of the Getic Subprovince. Its current outline is marked to the south by the Getic-Danubian boundary, to the west by the Haţeg and Strei basins, to the north by the Transylvanian Basin, and to the east by the Olt Fault. The district has a unitary character due to the intense metamorphism of the crystalline schists over most of its surface.

From a metallogenic point of view, there are obvious differences, leading to the separation of several metallogenic sectors: manganiferous, feriferous, pegmatitic, but also Ni and Fe metallogenesis associated with ultrabasic rocks. In the northern part of the Şurianu massif, associated with retromorphites, there is a complex metallogenesis with iron and manganese oxides, which is attributed an epigenetic character. The district comprises six metallogenic sectors, five of which are also located in Alba County.

a. The Sebeş manganese sector encompasses the concentrations of manganese ores and shales that occupy the central part of the Şurianu Mountains and the southwestern part of the Cindrel Mountains (Fig. 3). The sector comprises two metallogenic fields: *the Pravăţ-Bătrâna Field* and *the Răscoala-Frumoasa Field*.

The accumulations of manganese silicates and carbonates are lenticular-stratiform in nature, with

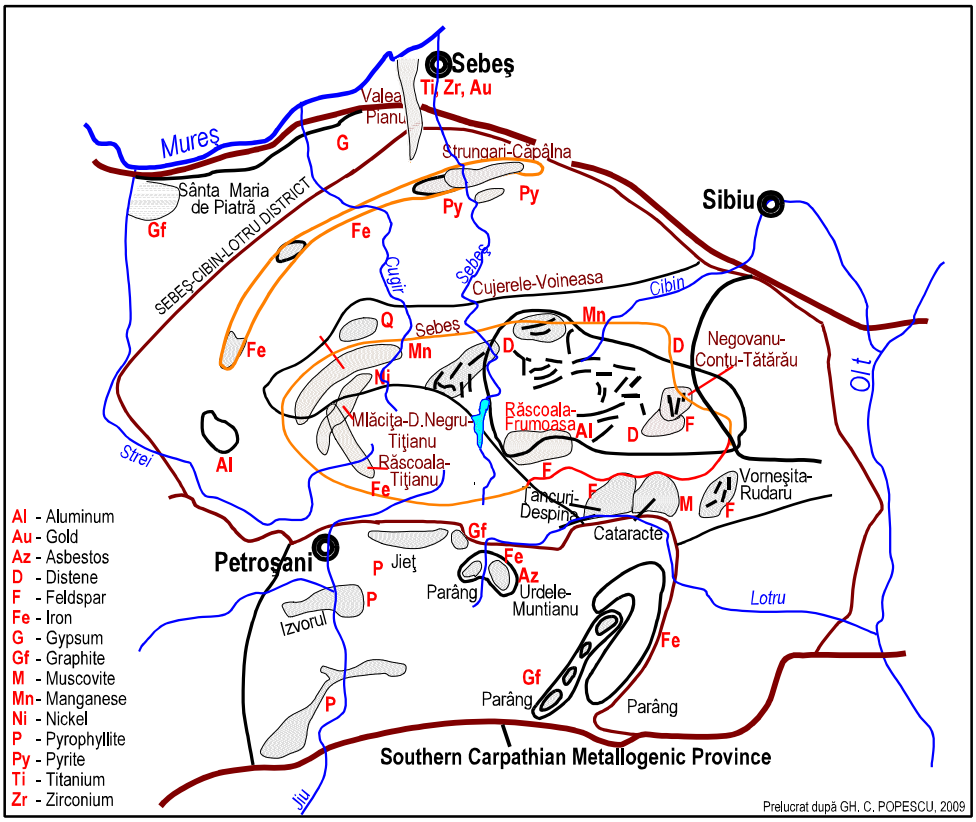

Fig. 3. Metallogenic map of the Şurianu Mountains

a thickness of 0.5-7 m, intercalated concordantly in mica schists, paragneisses, and quartzites.

The mineralogical composition includes: *spessartine, rhodochrosite, knebelite, pyroxmangite, rhodonite,* and *danemorite,* sometimes also *piemontite*. Secondary minerals have formed in the oxidation zone: *pyrolusite, psilomelane, goethite, lepidocrocite* and *hydrogoethite.*

The chemical composition of manganese formations indicates: Mn=23-33%, Fe=10-15%, to which SiO2, Al2O3, P2O5, CaO, and MgO are added.

The association of manganese-bearing rocks with mesometamorphic crystalline schists indicates the formation of manganese compounds in association with the minerals that make up the schists, in the process of high-intensity metamorphism, mesometamorphism-amphibolite facies. It is assumed that in the pre-metamorphic stage, iron and manganese hydroxides were deposited alongside sediments with siliceous gels, in the form of thin layers. Through progressive intense metamorphism, these reacted with silica, forming manganese silicates (*rhodonite*).

Various types of manganese silicate schists, found as intercalations, sometimes of considerable thickness, among mesozonal crystalline schists, are composed of: biotite paragneisses with garnets, biotite mica schists with garnets or sometimes with disthene, associated with biotite quartzites. Schists containing manganese silicates are reddish brown in color and very compact, the constituent manganese minerals being *spessartine, pyroxmangite,* and *rhodonite.*

b. The Răscoala-Tiţianu iron sector comprises magnetite accumulations in the form of concordant lenses, located in amphibolites, quartzites, and crystalline limestones, which are associated with paragneisses and biotite quartzites. The mineralogical composition includes: *hornblende, calcite, quartz, garnets, pyrite, pyrrhotite,* and *chalcopyrite*.

At Tiţianu, mineralization occurs in the form of discontinuous lenses of quartzites, amphibolic gneisses, and amphibolites with magnetite, located concordantly in paragneisses and mica schists. The thickness of the lenses varies between 0.2 and 1.5 m, and their length between 200 and 250 m.

c. The Ni and Fe accumulation sector at Mlăcile-Dealul Negru-Tiţianu. The occurrences of Ni and Fe mineralization are related to the serpentinite bodies located in the central area of the Şurianu Mountains. The mineralization consists of sulfides *(pyrite, pentlandite, chalcopyrite*) associated with *magnetite* and arranged as impregnations in serpentinites. The bodies are small in size, and the Ni content varies between 0.09-0.4%, the Fe content between 3-4%, to which are added some low contents of Cr and Cu. The mineralization is initially magmatic liquid, probably of liquefaction.

d) The Negovanu-Conţu-Tătărău disten sector encompasses two fields: *Colonia Bistra* and *Valea Sadului*, which are part of a larger area containing numerous occurrences of *disten* shales intercalated in the mica schist complex in the central area of the Şurianu and Cindrel Mountains. The form of presentation is that of concordant lenses, with variable thicknesses. *Distene* participates in the composition of the rocks in variable percentages of 5-3%. Often, however, *distene* is transformed into *muscovite* as a result of retromorphism, which leads to a decrease in its participation in the composition of distene schists.

e) The Strungari-Cârpiniş-Căpâlna-Cioclovina sector with epigenetic mineralization comprises three metallogenic fields: *Sibişel-Romoşel, Strungari-Căpâlna, and Cioclovina*

- *The Sibeşel-Romoşel metallogenic field* is represented by *magnetite* lenses associated with *pyrite* and *pyroxene*, intercalated in amphibolites and eclogites and/or in skarns. The mineralization is usually oxidized, represented by secondary iron minerals with an Fe content of 15%. Its genesis is uncertain: sedimentary-metamorphosed or pyrometamorphic.

- *The Struagari-Căpâlna metallogenic field* is represented by small siderite lenses intercalated in oristaline dolomites (Fe content is 22%) and by green schists with magnetite, contained in epidotic chloritic schists, quartzites, and quartzite schists. *Magnetite* is also associated with *siderite, pyrite,* and *Fe hydroxides*, but it also occurs in lenses and as impregnations in green schists. The Fe content is 9-10%. The genesis of these mineralizations is diverse: metamorphosed volcanic-sedimentary in the amphibolite facies for those in the south and in the green schist facies for those in the north.

- *The alluvial gold field at Pianul de Sus*. In the alluvial deposits of the Pianului valley, there are detrital accumulations of gold in the form of

grains, flakes, scales, nests, and rarely nuggets, scattered in the sand. The paragenesis also includes: *limonite, magnetite, hematite, zircon, rutile, pyrite, garnets, apatite*, etc. The minerals originate from the crystalline schists and eruptive rocks in the north of the Şurianu Mountains.

Also important from an economic point of view are the non-metallic mineral deposits present in the Şurianu Mountains, associated with all mesometamorphic and epimetamorphic rock complexes. This category includes pegmatites, the most important area of occurrence being in the Cugir River basin, Cujerele sector(fig. 1), where muscovite pegmatites and feldspar pegmatites occur (Horst, 1987). Within this area, there are three distinct areas where pegmatite bodies are concentrated, namely in the Cugir valley (where veins 50-150 m long and 1-5 m thick occur), in Dealul Cujerele, and in the Dealul Cujerele -Izvorul Căldării valley area.

At the confluence of Izvorul Căldării and Cugir valley, there is an east-west oriented vein consisting of plagioclase (50-70%), quartz (15-40%), muscovite (5-15%), microcline (0-8%) and K_2O contents between 0.6-1.8% and Na_2O between 2-6.1%.

Pegmatite bodies are also found in the Bistrei basin, where microcline pegmatites are frequently observed.

In the area between the Cugir and Sebeş valleys, numerous concordant pegmatite bodies are described, rarely discordant, sometimes zoned (zonation given by the increase in mineral grain size).

The main areas of pegmatite outcrops are located in the upper basin of the Izvorul Căldării stream, the middle basin of the Cugir Valley, and the middle basin of the Gâlceag Valley, as well as in the basins of the Dobra and Gâlceag valleys.

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