GEOPHYSICAL CONTRIBUTIONS TO UNRAVELLING SOME TECTONIC AND METALLOGENETIC STRUCTURAL ASPECTS IN THE OAS-GUTĂI-TIBLES MOUNTAINS AREA

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The paper presents the results of geophysical and geological data integrate interpretation performed by the author in time, within the Oas-Gutai-Tibles Mountains Neogene volcanic chain, referring to the pre-Neogene basement structure and tectonics of the region, to the structure of buried Neogene volcano in the Livada zone and to the geoelectrical methods contributions to the vein mineralization research, with examples on the Cavnic-Roata mineralized structure.

The Oas-Gutai-Tibles Mountains represent the north-west segment of the Neogene volcanic range of the East Carpathians on the Romanian territory.

According to Kovacs’ model (in press), the volcanic segment of the Oas-Gutai Mountains was generated by magmatic processes from the Alcapa microplate (partly also in Tisia-Getia) due to European plate subduction below it. The beginning of the volcanism took place at about 7-6 M.a., from the beginning of the Miocene subduction (22 - 20 M.a., in the Burdigalian, respectively). The volcanism in the Oas-Gutai-Tibles Mountains took place during the oceanic lithosphere subsidence and using-up, having the climax a little earlier than the continental plates collision (considered to occur at about 10 - 9 M.a.). It has a calc-alkaline character, specific to subduction zones.

The general geological structure of the Oas-Gutai-Tibles Mountains includes, apart from volcanites and sedimentary formations of the Neogene adjacent basins, structural units of the prevolcanic basement. These are part of the Transcarpathian flysch zone (Dumitrescu, 1962). This name was assigned to an area located between the Baicului-Ticau-Preluca crystalline islands in the South and East Carpathians Crystalline-Mesozoic zone to the north and east. It is made up of several tectonic units, considered as nappes of Lower Miocene age - Piennine nappes - represented by Babesti-Ticovo Nappe, Kricevo Nappe, Botizei Nappe, Piennine klippe, wildflysch nappe, Petrova (Magurs) Nappe, all these overthrusting the posttectogenetic cover of the units with Cretaceous tectogenesis (Inner and Middle Dacides).

Associated to the volcanic arch are the hydrothermal deposits that represent one of the largest zone with metallogenic potential in Europe - Baia Mare region. The hydrothermal mineralizations are of epithermal type, mostly polymetallic, but also gold at the upper part. The structural control of the mineralizations is tectonic and magmatic. The tectonic one is made up of the Carlibaba - Carei transcrustral fault and the strain fractures related to it (NE-SW and NW-SE). The structural-magmatic control is given by the batholite from the southern zone of the Gutai Mountains (to the extent this can be definitely proved) and by the complex volcanic structures, with associated intrusions. The mineralizations are of vein type and only subordinately of pipe breccia type. The vein has some hundred meters in length, up to 5 km ,and a thickness of 0.5-8 meters; the vertical extension is ranges between 300 and 1000 meters.

Within the Oas-Gutai-Tibles Mountains area, in the last 40 years the whole range of geophysical survey (gravity, air- and ground magnetism, air- and ground radiometry, electrometry, magneto-telluric logging, refraction and reflexion seismometry) was applied. In different stages, there were performed works on the geophysical data available at the respective
time including a series of structural and metallogenetic interpretative models. Also, there were performed 2D and 3D physical-mathematical modellings of the gravity and magnetic data presenting quantitative models in terms of structure of batholite in the southern part of the Gutai Mountains, of igneous rocks in the Livada zone, as well as the structure of crystalline and pre-Badenian sedimentary formations, of volcanics and Neogene sedimentary formations.

The present paper presents a series of the author's interpretative models, referring to the crystalline and pre-Badenian sedimentary formations structure, 2D gravity data modelling, on some seismic data from Livada zone directions, as well as a series of metallogene aspects deduced from geoelectric data interpretation in the Cavic-Roata zone and the adjacent areas.

The pre-Badenian basement structure is illustrated on maps with isobaths of the crystalline basement relief and of the pre-Neogene sedimentary formations relief (upper limit of the Paleogene), respectively. These images were obtained on the basis of 3D gravity modelling and of integrate interpretation of gravity and seismic data, in correlation with the results of the mining and drilling works.

Essentially, the structural maps quantitatively show the very complicated morphology of the crystalline basement and pre-Neogene formations relief, because of an intense partition of the formations, in blocks, with relatively up and down moved positions, among which more ample or reduced unevennings, with more or less steep slopes occurred. The pre-Neogene basement partition was made according to three fracture systems, directed as follows: E-W, representing underlatitudinal fractures field with turnings towards ENE-WSW and, sometimes, WNW-ESE, out of which the most important is the Carlibaba-Carei line, NW-SE, representing G13 line (Gavat, 1963) fractures field and the new ones, directed NE-SW. Initially, the correlated action of the two first fracture systems caused or enhanced the axial up and down movements, often with outstanding extensions on the line, with general E-W directions in the central-western part of the area, and with NW-SE ones in the eastern part.

Subsequently, the fracture system with a NE-SW trending brought about the oblique-transversal fracture of the blocks individualized in the first stage of partition, giving to the pre-Neogene basement a mosaic aspect.

Referring to the buried volcanics, 3D magnetic data modelling (Crahmaliuc, 1998) presumes that in the Livada zone there are acid igneous rocks, intruded in crystalline formations, with a series of summits that also pierce Paleogene formations. The 2D gravity and magnetic data modelling on the path of some seismic lines crossing E-W and N-S this plutonite area, proves that, actually, there is an acid lava flow that moulds Paleogene and/or Badenian formations relief, specifying also the main volcanic systems that generated it. The unravelling of the deep evolution of the microdioritic subvolcanic intrusive body at Tamaseni, as well as the pointing out of other microdioritic subvolcanic bodies in the Dealul Mic - Turulung zone, was also possible.

An important role in the vein mineralizations research was played by geoelectric studies, by induced polarization and apparent resistivity methods, that often represent direct methods of outlining such mineralizations. For example, we mention the geoelectric research results in the Cavnic - Roate zone. It is a case study commenting the interpretative hypotheses at the date of performing these researches, in comparison with the results of the checking-up by mining works and drillings carried out subsequently.
STREAM-SEDIMENTS IN THE TÂRSA-OBÂRSA ZONE
(APUSENI MOUNTAINS, ROMANIA)

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Natural processes as erosion, conveyance, accumulation and concentration of mineral associations from a subaerial area into the hydrographic network represent a facility used in the geological survey by simple methods, as dosca and pan concentration and stream-sediment sampling, both scanning with high fidelity the gold and base metals deposits and their associated facies.

In 1998, we tried to establish the presence of alluvial gold by sluicing with dosca and pan in the Târsa-Obârsa area, Banatitic Province (Gaina Massif, Bihor Mountains). Besides, we sampled stream-sediments on a depth less than 0.30 m, and the fraction less than 1 mm was assayed for gold and spectral for other few elements.

This method of sampling stream-sediments at depth greater than usual offers more valuable information about the distribution of gold, which tends to concentrate in deep alluvial structures (recent unsorted sediments, small sand bank left above water surface after annual flood, gravel in the rim of minor riverbed etc).

The study of heavy minerals concentrate at binoculars revealed mineral associations as a result of worn-away primary lithofacies. They appear intermingled and reflect local geostructural configurations, as bellow:

- The chlorite, milky quartz, muscovite, magnetite, ilmenite, sphene, apatite come from denudation of green schist facies which lies in Ariesul Mic basin;
- The translucent and milky quartz, garnet, amphibole, biotite, tourmaline, etc., are the result of amphibolitic facies erosion, reiterated in the Upper Cretaceous sandstone, lain in the central-southern part of perimeter and in the Neogene deposits of the south-west side;
- The sugary cavernous quartz, the opalescent and the milky ones, feldspars, amphiboles, pyroxenes, zircon, apatite, sphene, magnetite, etc. proceed from felsic igneous rocks of the Banatitic Province;
- The amphiboles, pyroxenes, glauconite, calcite, ilmenite, magnetite issue from ophiolites occurring in the Obârsa and Ociu valleys;
- The translucent quartz, carbonates, epidote, sphene, magnetite, ilmenite, pyrite, etc., belong to the hornfels occurring in the Ociu, Obârsa, Vâlcele, Piau, Tomnatec, Giurgesti valleys;
- The euhedral garnets, frequently aggregated, brown, black and green colored, milky quartz, magnetite, sulfides - occurring on the northern rim of Obârsa Banatite stock - come from...
skarns;
- The milky quartz, the microsugary and the euhedral ones, calcite, tourmaline, magnetite, ilmenite, iron hydroxides, sulfides, gold, etc., represent the entire association denudated from hydrothermal structures of the area and constitutes the main aim of our research. Based on local variations, the following sectors could be separated:
  Râul Mic, in which base-metal sulfides (Cu, Pb ± Zn) prevail;
  Rotunda – Divaia – Toha – Dobranii (Ariesul Mic), with much alluvial gold and less metal sulfides and silver;
  Tomnatec Valley - Giurgesti Valley, with Pb, Zn, sulphides and silver;
  Bulzesti valley-down-stream, with much gold and less pyrite, silver, concretionary lead;
  Darjaniilor Valley - Obârsa Valley - Vâlcele Creek - Piua Creek - Baia lui Adam, with pyrite and gold in alluvia and in an old waste-dump;
  Ociu Valley - Certej Creek - Tarnita, with pyrite, sporadically galena, sphalerite and much alluvial gold.

Figure 1, representing the distribution of alluvial gold, reveals clusters of samples with a high content in the north and south of the area.
As for the origin of alluvial gold, the autochthonous character is obviously given by the hiatus of the Neogene transgression over the Cretaceous deposits or over the crystalline formations within the area (this one could have released, by erosion, an allochthonous gold belonging to the southern Neogene metallogenic province).

The morphologic features of gold, dominated by subisometric granular shapes, slightly elongated and flattened, smaller (0.1-0.5mm), but with complex, amoehial, bigger shapes (Baia lui Adam, Divaia, Toha, Bulzesti down-stream), or even like grains preserving the outline of a crystal (Baia lui Adam) plead for a weak transport or even a break of it (Baia lui Adam case).

Nevertheless, it is possible that the alluvial gold at Golfesti (Ociu Valley), at the south-western limit of the area, much quantitatively and with large size of grains (3-4 mm), found in the contact zone with the Neogene formations, to have an allochthonous feature in relation with the Banatitic province.

The distribution of the metal contents in alluvial samples (unconcentrated, taken at depth of 0.30 m) charged the elements: Au, Ag, As, Cu, Pb, Zn.

Hight contents of Cu, Pb and Zn have been noticed in the north-western part of the area (Râul Mic - Divaia Valley - Ariesul Mic - Halmagel Valley), marking a well-known sector mineralized with metal sulfides and gold (Râul Mic) and new ones (Divaia Valley - Ariesul Mic - Halmagel Valley), previously recorded only by silver sulphides mineralization occurring at the issue of the Halmagel valley.

The contents in As and Au have different distributions in relation with Cu, Pb, Zn ones and each other. High contents of gold have been pointed out in the northern part, in Divaia Valley, Toha, Paltinis, Dobranii, Ariesul Mic, and lesser in the south, in the Obarsa Valley, Inelului Creek and Stanculesi Creek.

The study of alluvia concentrates in the central-eastern part of the Bihor Mountains completes the images of the Banatitic metallogenesis with a developed stage of macroscopic free gold.

The authors’ experience gathered in the last years in gold survey domain, beside the actual technology of the unit, suggests the adoption of methods - geological, geochemical, geophysical - gradually and efficiently blended. The progressive survey, by the complex study of alluvia (stream sediments, heavy minerals concentrating on dosea and pan, inventory of metallogenic litters) leads to the fast identification of sectors with metallogenetic processes. Then, geological and geochemical survey focused on these sectors could bring new data for the future particular steps of detailed research just on these well-established structures.

THE MIOCENE ROTATION OF THE FORELAND IN FRONT OF THE SOUTH-EAST CARPATHIAN BEND

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The numerous papers published so far concerning the tectonic evolution of the Carpathians have failed to explain satisfactorily the formation of the important bend as well as its great subsidence.

The presence of some thrust faults in the foreland (end Badenian - Early Sarmatian) genetically related to two major strike-slip faults, the change of direction of some former
foreland structures, the coeval formation of compressional structures and extensional ones, account for the clockwise rotation model of the block confined between Intramoesian, Peceneaga-Camena and Trotus faults (the last fault is indicated only as position because it was not involved in the deformation at that time).

The occurrence of block rotations inside a shear zone is well known. Obviously, due to the space problems needed by the accommodation of rotations, the corners of the block involved in rotation determine compressions; “triangle” extension zones appear, as well.

During the end Badenian - Sarmatian the Moesian Platform underwent a strike-slip deformation carried out on NW-SE fault system.

Since the motion along the Intramoesian fault (see also the figure) was greater than that on Peceneaga-Camena fault and due to the rheology difference between the Moesian Platform and North-Dobrogea Promontory, the rotation of the block and the areal distribution of the zones which experienced extension and compression, respectively, were controlled in the eastern part by a couple of antithetic shears (senestral).

The north-eastern and south-western corners experienced compressions accommodation by two thrust fault systems in Birlad zone and Lipia-Conduratu, respectively (the latter is covered to the north-west by the Subcarpathian Nappe).

The western edge of the block recorded the greatest subsidence and corresponds to Sarmato-Pliocene Zone, the model of rotation explaining well this important accommodation space for the sediments.

Although the thrust system did not record reactivation after that time, the fact that Intramoesian fault is being active at present could account for some earthquakes recorded in Vrancea area.

THE EVOLUTION OF THE LITA - NENCIULESTI - TALPA FAULT SYSTEM AND THEIR INFLUENCE FOR THE SEDIMENTARY SEQUENCES AND HYDROCARBON POTENTIAL

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This paper presents the Lita - Nenciulesti - Talpa fault system evolution and its implication in the Upper Jurassic - Albian sedimentation.

This fault system is situated in the central area of the Moesian Platform, partially superposed on the so-called Rosiori-Alexandria Depression. It was recognised and tracked discontinuously many years ago, but the existing papers did not try to point out its character.

Further more, many paper on facies distribution have been published on this area but exclusively based on well data.

The Lita - Nenciulesti - Talpa fault system has a roughly semicircular SW - NE shape and cuts Permo - Triassic or older up to Miocene - Pliocene ones suggesting that they could be active to data.

The features of this fault system suggest a strike slip type with left-lateral movement.

The evolution of this fault system influenced the sedimentation especially for Upper Jurassic - Neocomian time. The area on the foot well block was favorable to reef and another carbonate build - ups all along the fault trend during Lower Cretaceous.
The area on the hanging well block was favorable for a turbidite facies and to fan depositional system sedimentation on the same time.

The long time evolution of the fault system influenced, may be favourably the hydrocarbon potential of the areas situated around them.

GEOLOGICAL, TECTONIC AND METALLOGENETIC SYNTHESIS OF THE EAST CARPATHIANS CRYSTALLINE-MESOZOIC ZONE (ROMANIA)

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The lithostratigraphic successions of metamorphic formations in the Central-East Carpathians are distributed to five base lithostratigraphical groups (litho-groups): Bretila, Rebra, Negrisoara, Tulghes and Rodna. The Rodna Group, according to Balintoni (1997), comprises the Rusaia, Repedea and Cimpoiasa Variscan series in the Rodna Mountains. Some metamorphical rock successions with limited extensions, like Argestru, Tibau and Steghioara series, are located in zones with strong distortions in the Bucovinian and Subbucovinian nappes basement. Chiril, Mandra, Poiana Grebin and Balaj series, present only in the western part of the Rarau Prealpine Nappe occurrence, in the Bucovinian Alpine Nappe, are considered as parts strongly distorted in the Rarau Prealpine Nappe basement (Voda, Balintoni, 1994).

Structurally, the general background is that described in the papers published by Sandulescu (1984) and Balintoni (1997), extended also in the Maramures Mountains. There were considered the frontal digitations of the Bucovinian Nappe: Sadova, Tarnita, Grebin, Chicera. The Subbucovinian Nappe digitations, delimited in the Bistrita Mountains (Krautner et al., 1990; Podasca, Moga, 1992; Voda, Munteanu, 1995), named Sveiteria, Dadu-Orata, Tonca, Litu and Stanei Valley, are considered stemming from the inner (western) part of the Subbucovinian domain, next to the domain from which Bucovinian Nappe frontal digitations came.

The East Carpathians Crystalline-Mesozoic Zone is partitioned by important transversal faults, with detachments of complex evolution, inclusively before the Mesocretaceous tectogenesis. With obvious effects there are: Vaser Fault, Dragos-Voda Fault, Somesului Fault, Crucea-Zugreni Fault and Darmoxa-Grinties Fault.

Noteworthy is the observing of Miocene retro-overthrust (retro-chevauchement) zone limitation in the Maramures Mountains at the tectonic compartment limited by Dragos Voda Fault and Vaserului Fault.

South of the Darmoxa-Grinties Fault, Putna Prealpine Nappe in the Bucovinian Nappe bed is made up of the Tulghes Group successions, having different features and limited as prealpine overthrust nappe: Sandominic Nappe and Balan Nappe (Krautner et al., 1988) in the South Gheorgheni region. More complicated is the situation of the units made up of formations of the Tulghes Group in the Tulghes zone, where there several structural units were delimited: Banatul Mare, Corbu, Sandominic (Ionescu, 1999). Under similar conditions, in the Harlagia zone, two structural prealpine units were considered as being digitations of the Putna Prealpine Nappe in the Bucovinian Alpine Nappe bed. The interpretation uniformizing imposes consideration of the Balan Nappe and Sandominic Nappe as Putna Nappe (Voda, Munteanu, 1998) prealpine digitations, upper and lower, respectively.
Recent results obtained by drillings at Sarul Domei, where, under the Borcut-Ulm Infrabucovinian Nappe, inferior to the Iacobeni Infrabucovinian Nappe, was intercepted a slightly metamorphosed formation, Variscan, easily correlatable with the upper part of the Rusaia Series, determined a new analysis of the Infrabucovinian structural units situation. There are, for the first time, expressed relations between the Infrabucovinian units with Permian and Mesozoic sedimentary covers and those in the Rodna Mountains, without Mesozoic sedimentary covers and having not demonstrated the alpine age. Thus, in the Vatra Domei - Sarul Domei zone, the geometric arrangement of the structural units known under the Subbucovinian Nappe is (from top to bottom): Iacobeni Nappe, Borcut-Ulm Nappe, Sar Nappe (in drillings). At Rusaia, Iacobeni and Borcut-Ulm the lnfrabucovinian Nappes are missing, as well as in the Rodna Mountains. These spatial relations argue an external initial position for the structural units with Variscan covers, at least over the Iacobeni and Borcut-Ulm domains. It is possible that the position of the Rodna Mountains type units should mark a prealpine relationship, of other type than those recognized in the Bucovinian and Subbucovinian protodomains.

The East Carpathians Crystalline-Mesozoic Zone metallogenesis shows multiple aspects. The most important metallogenic processes are those in correlation with the basinal context of successions containing syngenetic ores. Thus, the Vaslabeni Carbonatic Formation, of the Rebra Group, contains Valea Blaznei Pb-Zn mineralizations (Udubasa et al., 1983), formed under conditions of carbonatic sediments on a passive continental margin zone. The well-known sulphide mineralizations of the Tulghes Group, from Baia Borsa, Fundu Moldovei, Lesu Ursului and Balan, as well as manganese (Dadu-Orata-Oita; Iacobeni; Dealul Rusului) and baryte (Holdita-Brosteni) mineralizations can reflect a metallogenesis related to the basinal evolution in subduction context, of back arc type basin. The relationship between mineralization and rhyolitic volcanism is of geotectonic context; the acid volcanism products come from the arc, whereby the ore deposit is fallen out in a marginal basin.

Another chapter is represented by the epigenetic alpine mineralizations - related to the contraction period from Upper Triassic - Middle-Upper Jurassic, effect of the Transylvanian Ocean, eastern zone and Outer Dacides opening. There are especially known the mineralizations of the Bucovinian Nappe and Subbucovinian Nappe, of baryte (Ostra, Pintec, Pangarati), of baryte, sulphides, carbonates and iron oxides (Gemenea, Slatioara, Delnita), sulphides (Paltin, Fluturica), uranium (Crucea, Tulghes) and those of Mo, TR, Pb, Zn etc., related to the Ditrua alkaline massif.

In the presented metallogenetical systematizing, the mineralizations of “shear zone” type, in course of research at Sarul Domei and Cosnita, in the Infrabucovinian Nappes of Borcut-Ulm and Iacobeni, are inserted for the first time in the East Carpathians.