IS THERE A FUTURE FOR OIL AND GAS EXPLORATION IN ROMANIA?

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ABSTRACT

Romania is classified as a mature hydrocarbon province, but it is still the most important producer in the Central and South-Eastern European countries. Oil production in Romania has steadily declined over time. Even if the earlier discovered fields have a high rate of depletion and the new discoveries do not compensate entirely for the consumption, Romanian sedimentary basins have petroleum prospectivity. Thus, significant hydrocarbon potential remains in exploration, near-field opportunity and field rehabilitation.

Significant oil exploration potential is still present in Romania. The general trend is near-field opportunity, going deeper and applying new technologies (3D seismic surveys, regional long-offset 2D lines for structurally complex and deep leads/prospects, AVO analysis of shallow targets and 2D/3D structural balancing) and new concepts (subtle traps).

There is still an ongoing effort to redevelop mature oilfields in Romania; currently are used technologies as directional drilling, steam injection, water injection, polymer injection, and in-situ combustion.

Romanian hydrocarbon basins have still areas with oil and gas resources entrapped in all kind of traps, especially subtle ones, and there is a great chance for new commercial discoveries. Potential new discoveries in Romania of conventional oil and gas fields are connected with foreland plays in little explored deep, subtle traps, deep overthrusted structures and deep offshore area. New oil and/or gas fields could be discovered at shallower depths in traps overlooked as a consequence of poor seismic results or insufficient research. The resource appraisal simulation for petroleum prospects analysis in Romania confirmed that the new prospects are primarily gas prone.

The skills and the ability of exploration geoscientists will play an important role in any future success. The current Romanian proved reserves of 600 MMBOE oil and 100 BCM gas could be significant improved in the next years.

In the paper, we have underlined some future targets in the exploring for oil and gas in the main Romanian hydrocarbon basins.

Keywords: *Romanian hydrocarbon basins, oil and gas resources, oil exploration potential, future targets, new technologies*

INTRODUCTION

Romania is one of the most important hydrocarbon provinces of Central and South-Eastern Europe. Oil production started in 1854 and since then over 950 oil and gas fields have been discovered. The cumulative oil production exceeded 5.30 billion barrels oil whereas cumulative gas production exceeded 44.2 trillion cubic feet. [1], [2]

In the geological framework of the Romanian territory, the major structural element is represented by the Carpathian Orogen, part of the greater Alpine Orogenic belt. In front of the Carpathians there are located the platform areas (Moldavian Platform, Scythian Platform, and Moesian Platform). Between East and South Carpathians and the foreland, the Carpathian Foredeep (Pericarpathian Depression) is defined (in its turn divided in Miocene Zone, Diapir Folds Zone, and Getic Depression). The three branches of the Romanian Carpathians confine the Transylvanian Basin and, in the western part of Romania the Pannonian Basin is developed.

The major structural units with hydrocarbon potential correspond to the orogenic type basins (Transylvanian, Pannonian, Carpathians Flysch and Molasse), or to the foreland type basins (Moldavian Platform, Moesian Platform, Western Black Sea Basin). We can talk about thermogenic petroleum systems (Carpathian, Pannonian, Moesian, Euxinic), or biogenic ones (Transylvanian, Pericarpathian, Euxinic) (fig. 1). [3]

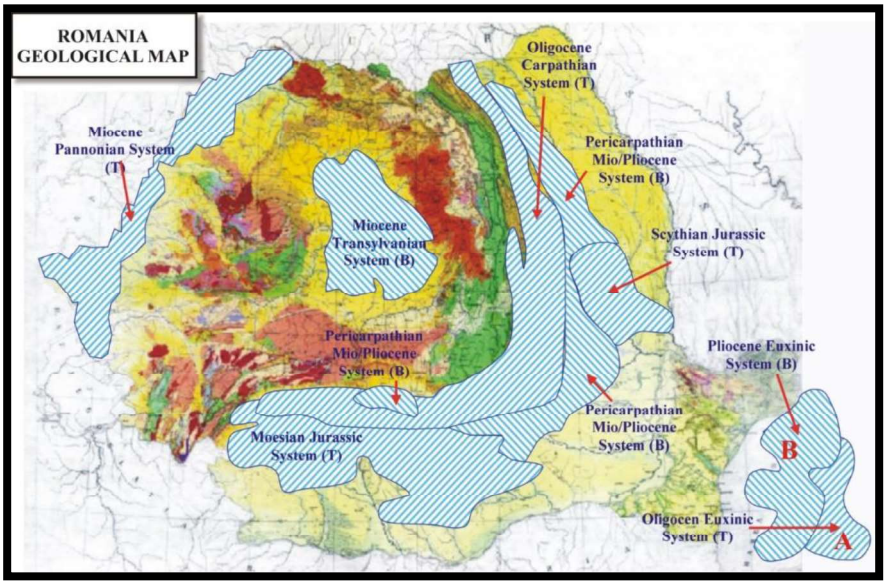

Figure 1. Distribution of petroleum systems in Romania. [3]

GEOLOGICAL SETTING

Eastern Carpathians. The outermost Eastern Carpathians are thin-skinned nappes built by Late Cretaceous to Early Miocene foredeep sediments thrust over the Eastern European margin during the Miocene. This was a typical soft collision process where deformation was accommodated by thin-skinned in-sequence deformation. Later, in the Pliocene, due to the locked collision boundary, thick skinned inversion of basement structures occurred along with crustal-scale folding and uplift of the entire Carpathian Orogen. The petroleum system consists of Oligocene and Lower Miocene source rocks (menilite and dysodile shales), Paleogene to Lower Miocene turbidite sandstone reservoirs, and traps formed by structural closures, mostly faulted anticlines. [1], [2], [3], [4], [5], [6]

Diapir Folds Zone (Eastern Carpathian Foredeep) is so far the most prolific hydrocarbon province in Romania. During more than 100 years of exploration and production, over 50 oil and gas fields in the Pliocene, Miocene, and Oligocene have been discovered in the region. Diapir Folds Zone is characterized by the presence of salt-cored folds. Generally salt tectonics resulted in forming of asymmetric faulted anticline, faulted monocline, thrust folds. The petroleum system consists of Oligocene dysodiles shales and menilites considered the main hydrocarbon source rocks and Neogene black marlstones and claystones are likely secondary sources; all are thought to be at their maximum thermal maturation. The oil and gas are stored in Oligocene to Upper Pliocene reservoirs in structural or combined traps. [1], [2], [3], [4], [5], [6]

Getic Depression is also one of the most prolific areas for hydrocarbons in the Carpathian Orogen and evolved during Tertiary time as foredeep of the Southern Carpathians. The overall compressional tectonic regime was manifested by mostly thin-skinned in-sequence deformation of which the magnitude increases from west to east. Thick-skinned inversion of former extensional faults has been observed as well, mainly in the western part of the basin. The petroleum system consists of Oligocene marine source rocks that produce oil and gas stored in Oligocene to Pontian reservoirs in structural or combined traps. Trap formation is Middle Miocene with a minor reactivation during the Late Pliocene event. [1], [2], [3], [4], [5], [6]

Transylvanian Basin is a relatively cold back-arc basin known as a biogenic gas province. The biogenic gas is sourced from deep-marine Middle Miocene shales and is stored in multi-stored turbidite reservoirs in structural traps, frequently salt-cored folds. Exploration started 100 years ago and more than 80 gas fields were discovered in the so called “gaseiferous“ formation which includes over 3,000 meters of Badenian, Sarmatian and Pliocene deposits. [1], [2], [3], [4], [5], [6]

Pannonian Basin is a Miocene extensional back-arc basin system. The petroleum system is represented by Middle Miocene oil-prone syn-rift lacustrine shales source rocks and weathered basement rocks, shallow marine syn-rift reservoirs and Late Miocene post-rift turbidites reservoirs. Most discoveries lie in structural closures – faulted blocks or drape folds over basement highs. Stratigraphic traps are predominantly in Late Miocene turbidites that onlap basement highs. [1], [2], [3], [4], [5], [6]

Moesian Platform is also one of the most prolific petroleum province in Romania. The platform was involved in Paleozoic and Triassic compressional deformations, Permian-Triassic and Jurassic extension, and were weakly affected by the closure of the Alpine Tethys. The petroleum system are represented by Paleozoic and Mesozoic source rocks characterized by an effective thermogenic-medium geothermic gradient that produced oil, gas and condensate stored in Paleozoic to Pliocene reservoirs. [1], [2], [3], [4], [5], [6]

Moldavian Platform which represents the west-southwestern part of the East European Platform, is the oldest platform unit in Romania. The Moldavian movements generated a folded, complex tectonic structure in molasse deposits, and led to their over thrusting over the descending foreland, along a NNW-SSE system faults. The petroleum system consists of Paleozoic shales and Miocene shales source rocks that produced hydrocarbons (especially gas) stored in stratigraphic or combination traps of the Miocene clastic reservoirs (sourced mostly by Sarmatian shales). [1], [2], [3], [4], [5], [6]

Western Black Sea Basin represents the Cretaceous back-arc of the Pontides and is one of the most promising hydrocarbon-bearing areas in the South-East Europe. Its hydrocarbon potential has been proved by the oil and gas fields discovered on the Romanian shelf. The Western Black Sea Basin is characterized by a variety of traps and reservoirs. Two different petroleum systems are recognized in the Western Black Sea Basin: Mesozoic (thermogenic) and Pontian (biogenic). The Mesozoic petroleum system consists of an oil-rich source, likely Early Cretaceous, which charge Mesozoic and Eocene limestones. This system is likely over-mature in the deep offshore. The Pontian petroleum system is formed by dry-gas found in deltaic sands on clinoform topsets. Some of this gas is biogenic sourced by Pontian shales, but thermogenic components are present, likely charged by the Oligocene. [1], [2], [3], [4], [5], [6]

FUTURE TARGETS IN OIL AND GAS EXPLORATION

Eastern Carpathians. Exploration targeted relatively shallow traps with more than 50 oil and a few gas fields being discovered. Current exploration continues to look for opportunities in the shallow section, but also considers near-field opportunity and going deeper, where potentially large gas structures exist. The presence of these is suggested by seismic data backed by structural balancing. These deep structures (fig. 2) developed in the Oligocene-Early Burdigalian and were subsequently modified by continued deformation on deeper detachments. [1], [2], [3]

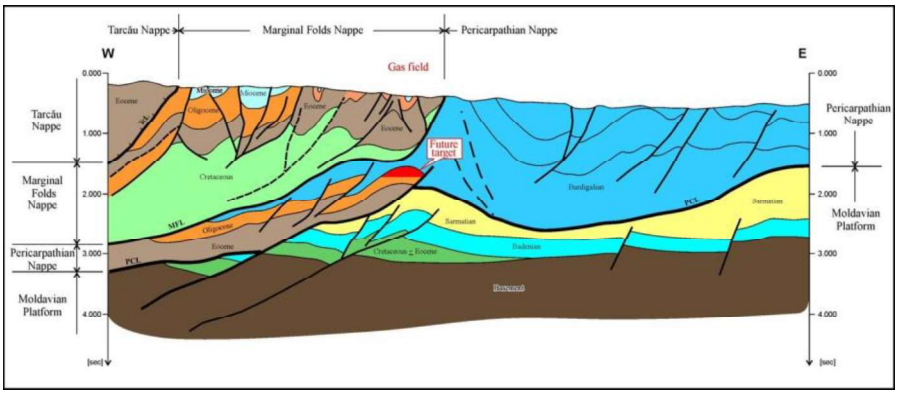

Figure 2. Geological cross-section in the Eastern Carpathians. [7]

Diapir Folds Zone. Analysis of geophysical and wells data in conjunction with information from the literature indicates that Oligocene-Lower Miocene source rocks played the most important role in thermogenic hydrocarbons bearing. So far the Oligocene deposits of high and even medium depths did not have results comparable with the potential of hydrocarbons generation and the volume of traps. Future exploration targets (fig. 3) are representing by near-field opportunity and Tertiary deep faulted anticlines, roll-over anticlines, truncations and pinch-outs, paleovalleys. [1], [2], [3]

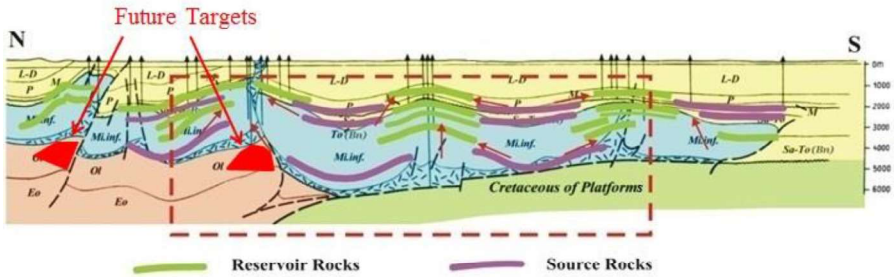

Figure 3. Geological cross-section in the Diapir Folds Zone [3]

Getic Depression. Exploration focused on relatively shallow depths (2-4 km), where large undiscovered traps are unlikely to exist to date. New play concepts focused on deeper levels (4-6 km, i.e. the Paleogene of the Getic Basin and the Mesozoic of the under thrust Moesian Platform), where potentially large gas accumulations are present. This is suggested by the current – yet low quality seismic data, backed by new balanced structural models and basin modeling. Future exploration targets (fig. 4) are representing by near-field opportunity and Tertiary deep faulted anticlines, roll-over anticlines, truncations and pinch-outs, paleovalleys. [1], [2], [3]

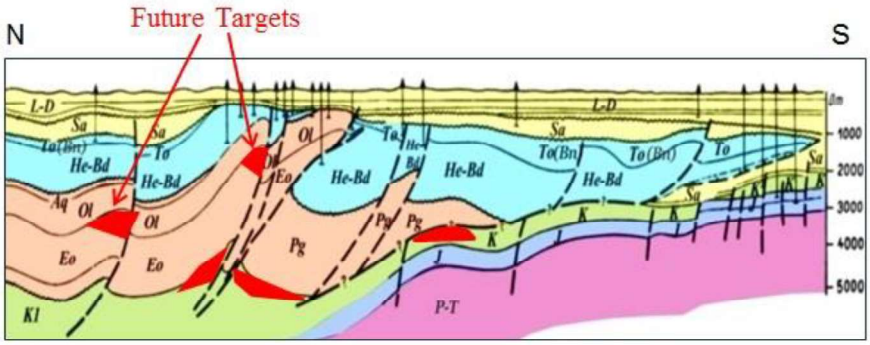

Figure 4. Geological cross-section in the Getic Depression [3]

Transylvanian Basin. Today, limited exploration potential is left in structural closures. Most prospective areas (fig. 5) are the slope channels and fans in the northern and eastern part of the basin, subsalt Mesozoic and Paleogene formations in structural traps in the center part. [1], [2], [3]

Pannonian Basin. Future exploration targets (fig. 6) are associated with structural or stratigraphic traps in the deeper Miocene, paleo-deltaic systems or roll-over structures of Upper Miocene-Pliocene. The "basin-center tight gas" play that is currently explored in the Hungarian part of the basin extends into Romania as well. [1], [2], [3]

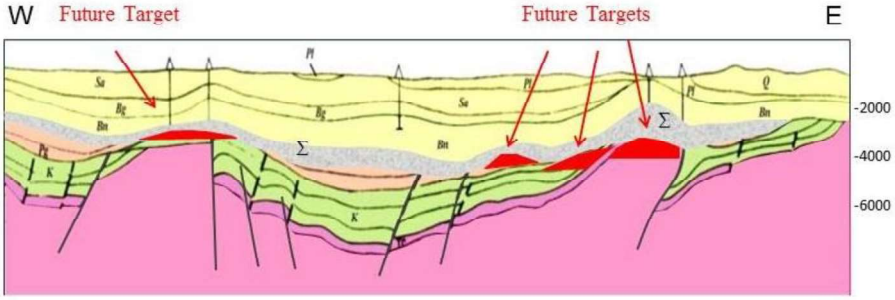

Figure 5. Geological cross-section in the Transylvanian Basin [3]

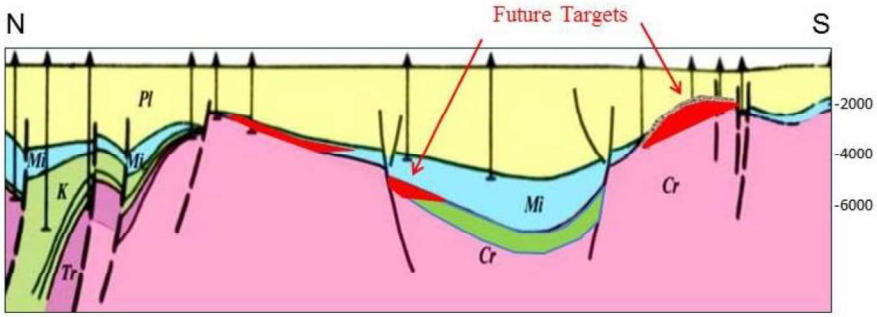

Figure 6. The Geological cross-section in the Pannonian Basin [3]

Moesian Platform. The unconventional shale gas potential of Silurian to Lower Devonian and Middle Jurassic shales is being investigated. The most prospective areas of the platform are the Permian to Triassic rift shoulders because the shales seems to be in the gas window and relatively shallow for drilling. For the future, near-field opportunity and, in the platform southern part, the subtle traps in carbonate deposits (facies variations, karst phenomena, diagenetic processes) are very important. [1], [2], [3]

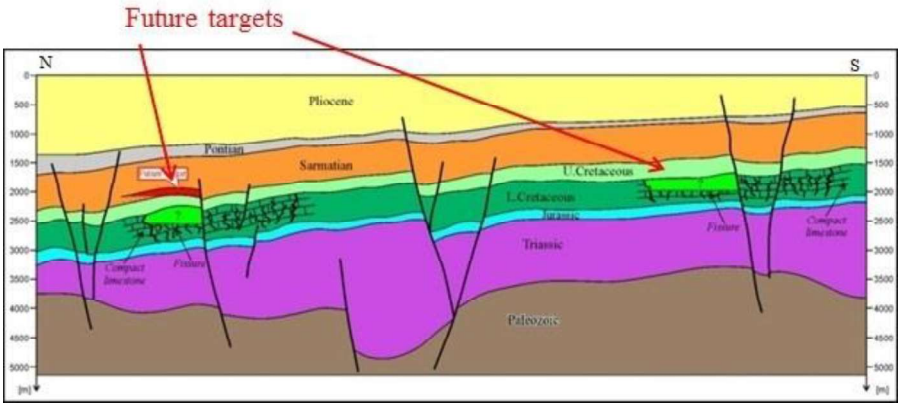

Figure 7. The Geological cross-section in the Moesian Platform [3]

Moldavian Platform. The western part of the Moldavian Platform at the contact with East Carpathian Orogen proved to still contain many hydrocarbons prospects, especially gaseiferous ones in deep Badenian and Cretaceous faulted anticlines or in deltaic Sarmatian sediments. [1], [2], [3]

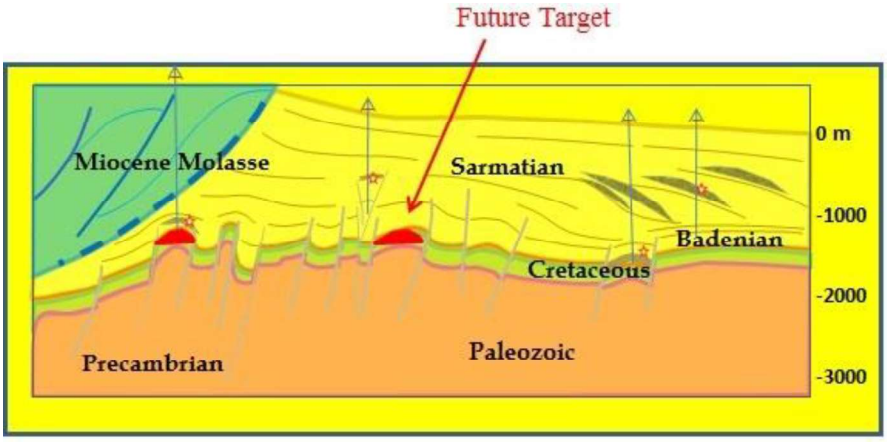

Figure 8. The Geological cross-section in the Moldavian Platform [3]

Western Black Sea Basin. The basin presents conditions for biogenic gas accumulation in Upper Pliocene/Pontian sands, clay sands and thin sandstones in

large anticlines, or in subtle stratigraphic traps (turbidites, paleovalleys). The source rocks can be the hemipelagic Upper Miocene-Pliocene lutites deposited during transgressive events, in medium geothermal gradient conditions. The main traps are structural type and are related to euxinic threshold. Recent 3D basin modeling results confirm that the Maykop section is in the early oil to wet gas window in the deeper part of the Romanian Black Sea and is getting more mature towards the central parts of the basin. The expulsion of hydrocarbons has started during the Late Miocene and is ongoing today. Current exploration continues in the shallow section, but there are attempts to open new plays represented by slope and basin-floor fans located farther offshore in the basin. [1], [2], [3]

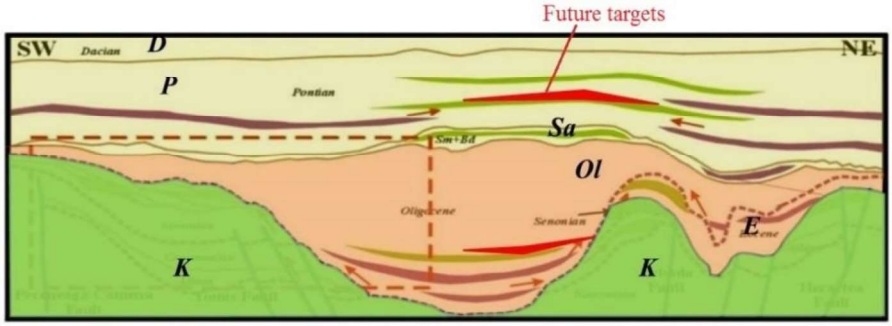

Figure 9.The Geological cross-section in the Western Black Sea Basin [3]

CONCLUSIONS

In the Romanian territory, most of the geological units of the Carpathians (especially the External Carpathians) and their foreland gathered the geological, geochemical and thermodynamic requirements for oil and gas generation, accumulation and preservation. Romanian hydrocarbon basins have still areas with oil and gas resources entrapped in all kind of traps, especially subtle ones such as structural uplifts, deeply faulted anticlines, paleo-deltaic systems, turbidites, truncations, pinch-outs, channels, reefs, diagenetic structures, strike-slip structures, diapir structures.

Romania is classified as a mature hydrocarbon province, but significant hydrocarbon potential remains in exploration, near-field opportunity and field rehabilitation. Significant oil exploration potential is still present in Romania. The general trend is near-field opportunity, going deeper and applying new technologies (3D seismic surveys, regional long-offset 2D lines for structurally complex and deep leads/prospects, AVO analysis of shallow targets and 2D/3D structural balancing) and new concepts (subtle traps). Regarding field rehabilitation, the most beneficial technologies are 3D seismic, directional drilling, fracturing stimulations and enhanced oil recovery.

The skills and the ability of exploration geoscientists will play an important role in any future success. The current Romanian proved reserves of 600 MMBOE oil and 100 BCM gas could be significantly improved in the next years.

REFERENCES

[1] Krezsek, C., Petroleum Systems of Romania, Search and Discovery Article #10349 (2011), AAPG European Region Newsletter, June 2011.

[2] Branoiu, Gh., General framework of exploration and production activities in Romania, 174 p., Editura Universităţii Petrol-Gaze din Ploieşti, 2019.

[3] Stoica-Negulescu, E.R., Romanian oil and gas from geophysics to petroleum systems, 97 p., Editura Vergiliu, Bucharest, 2015.

[4] Stefanescu, M., Dicea, O., Butac, A., Ciulavu, D., Hydrocarbon geology of the Romanian Carpathians, their foreland, and the Transylvanian Basin, in J. Golonka and F.J. Picha, eds., The Carpathians and their foreland: Geology and hydrocarbon resources: AAPG Memoir 84, pp. 521-567, 2006.

[5] Ionescu, N., Exploration history and hydrocarbon prospects in Romania, in Popescu, B.M. (ed.) Hydrocarbons of Eastern Central Europe – Habitat, exploration, and production history: Berlin, Springer-Verlag, pp. 217-248, 1994.

[6] Paraschiv, D., Romanian Oil and Gas Fields, vol. 13. Institutul de Geologie si Geofizica, Studii Tehnice si Economice, Serie A, Prospectiuni si Explorari Geologice, Bucharest, 1979.

[7] Schultz, G., New potential for onshore discoveries in Romania, SEE Upstream Conference & Exhibition 2015, Bucharest, 2015.