PS Alpine Inversion, Neogene Tectonics and East Carpathians Foreland Hydrocarbon Traps*

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Abstract

The Alpine inversion and the Neogene evolution are proven to have a major impact on Eastern European hydrocarbon systems. The East Carpathians Foreland, part of the East European Plate, has a Precambrian basement and Paleozoic, Mesozoic and Miocene sediments. The sedimentary basin within the platform was highly influenced by the tectonic Orogen-Foreland relationship. The opening of Alpine Tethys, the Middle Cretaceous and Paleogene inversion and movements were accompanied by a partial removal of Mesozoic cover. Miocene tectogenesis forced the Outer Carpathian Flysch units to override the Neogene Tertiary Molasse Zone. The presence of hydrocarbons in this area is due to the association in a certain manner of reservoirs, traps and migration pathways. High resolution seismic records helped us to clarify the relationship between sedimentary basin dynamics and hydrocarbon distribution. The complex structure of molasse deposits is overthrusts on the foreland along of the NNW-SSE Pericarpathian Fault. The westward descent of the platform is achieved along some fault systems with the same orientation, affecting the basement and sometimes the sedimentary cover as well.

The duplex Paltinoasa-West Paltinoasa System faults are proven to play the most important role in structural traps alignments. The more or less eastward advancing of the Pericarpathian Unit surpassed or left behind the Paltinoasa Fault system. The interlining zones prove to be the most favourable for hydrocarbon structural traps. The vertical and the strike-slip neotectonic movements have also played an important role, as horst and graben structures were created on both sides of the longitudinal faults. Beginning with Alpine inversion and continuing with Neogene deformations, the area manifested differences in stress and subsidence. So, different types of hydrocarbon traps were formed: wide anticlines between normal faults (in the North), strong symmetric anticlines flanked by high-step normal faults and roll-over on reverse faults (in Central part), and large monoclinal structures (in Southern part). Depending on the stress in the area, the faults that affect the reservoirs may or may not be tight.

The base Neogene tectonic style suggested by the TWT isochronous map represents an essential element in establishing the perspective structural alignments and the geometry of the main faults. Seismic data show another alignment of structures further west, under the Pericarpathian Unit, at about 3000-3500 m depth. The stratigraphic traps are present in the Sarmatian deposits. After a short break at the end of

Badenian, when the Parathetys waters withdrew, sedimentation resumed, the first deposits thickness proving a continued subsidence process but with discontinuous character. The next sediments became more complex: sand and sandstones (even oolotic limestones), lacustrine and deltaic deposits. The delta-front sandy bodies are the main objectives for biogenic gas accumulations. During Upper Sarmatian the sedimentation continued only in the southern part of the platform. Seismic images and well correlations offered a new interpretation regarding the distribution of the productive levels. Even if the traps are litho-stratigraphic, the hydrocarbons distribution is tectonically controlled, being connected with westward descending, gravity collapse and pinch-outs within each step.

Although Moldavian Platform is the oldest platform on Romanian territory, only Mid-Upper Miocene reservoirs are productive. For Paleozoic and Mesozoic formations, protection disruption has influenced the preservation because of the major tectonic events that have controlled the structural evolution. While Alpine inversion had a negative impact, the Neogene development had a positive one.

Alpine inversion, Neogene tectonics and East Carpathians Foreland hydrocarbon traps

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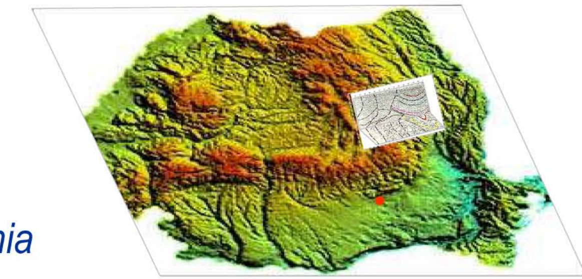


The Alpine inversion and the Neogene evolution are proven to have a major impact on Eastern European hydrocarbon systems. The East Carpathians Foreland, part of East European Plate has a Precambrian basement and Paleozoic, Mesozoic and Miocene sediments.

The sedimentary basin within the platform was highly influenced by tectonic Orogen - Foreland relationship. The opening of Alpine Tethys, the Mid Cretaceous and Paleogene inversion and movements were accompanied by a partial removal of Mesozoic cover. Miocene tectogenesis determined the Outer Carpathian Flysch units to get over the Neogene Tertiary Molasse Zone.

The special relationship between Pericarpathian Fault and the two Paltinoasa Faults are shown in Figure 1. Although all of them are almost parallel with Carpathians alignment, they are intertwined. Eastward advancing of Pericarpathian Unit goes either beyond Paltinoasa alignment, or gets left behind it with 4-5 Km.

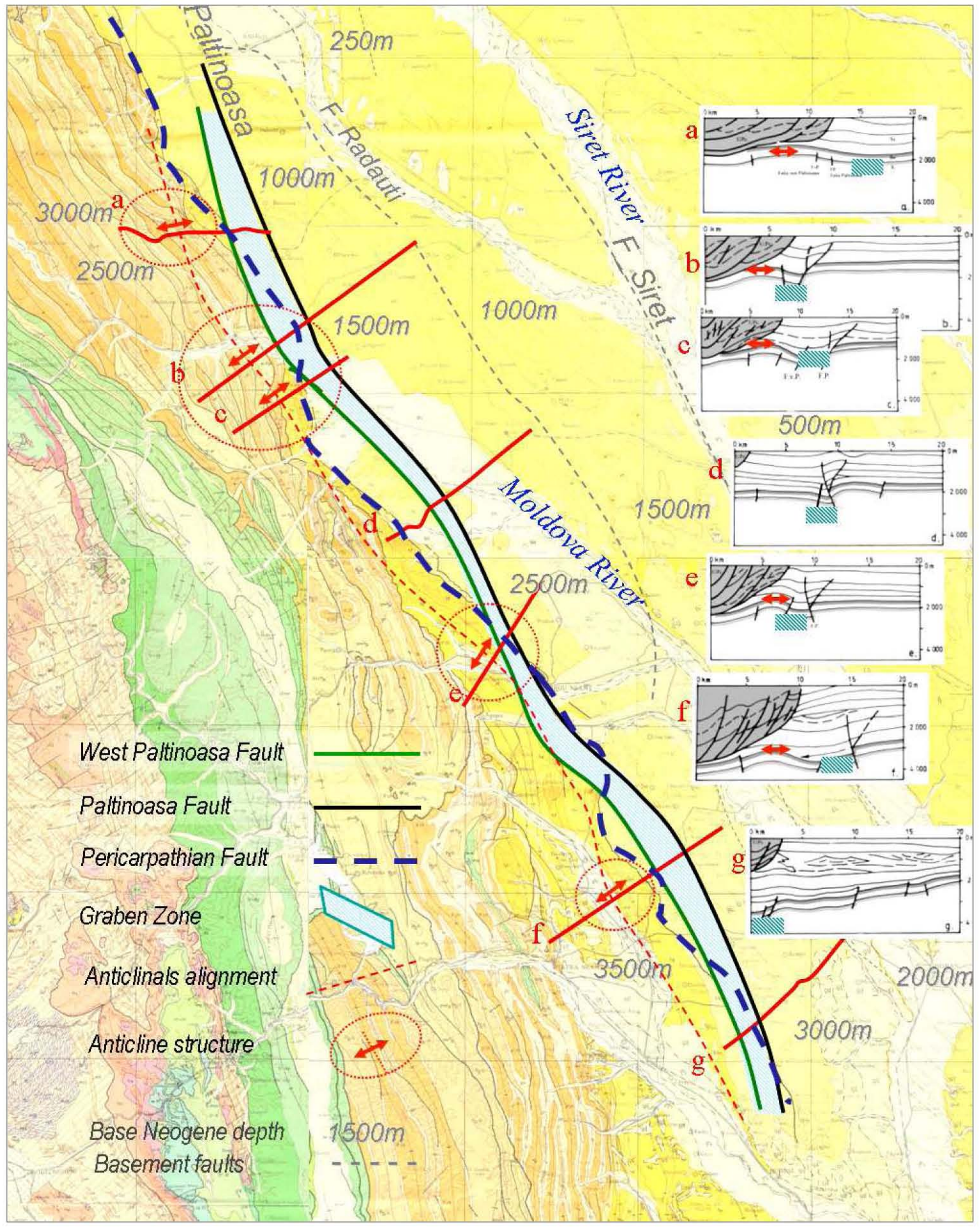


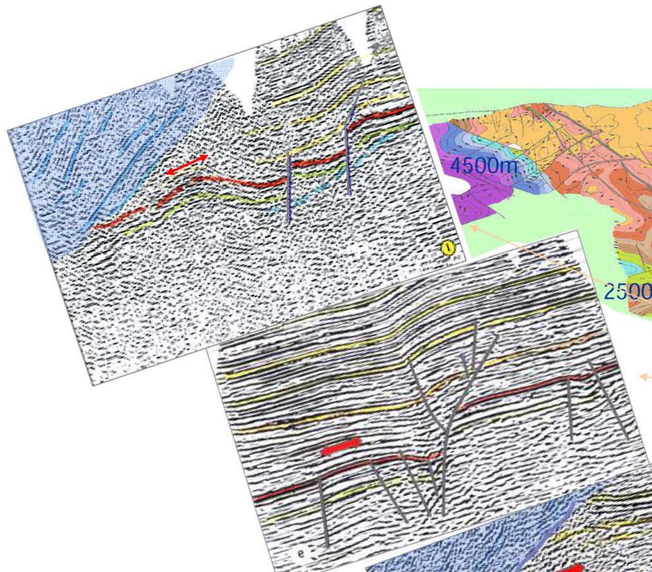
Fig.1 Relationship between Paltinoasa Faults alignment and Pericarpathian Fault in horizontal projection. Their intertwined areas are most favorable to anticline structures development.

The presence of the hydrocarbons in this area is due to the association in a certain manner of reservoirs, traps and migration pathways.

High resolution seismic records helped us to clarify the relationship between sedimentary basin dynamics and hydrocarbon distribution. Although Moldavian Platform is the oldest platform on Romanian territory, only Mid / Upper Miocene reservoirs are productive.

The complex structure of molasse deposits is overthrusts on the foreland along of the NNW-SSE Pericarpathian Fault. The westward descent of the platform is made along some fault systems with the same orientation, affecting the basement and sometimes, the sedimentary cover as well.

The duplex Paltinoasa - West Paltinoasa System Faults is proven to play the most important role in structural traps alignments. More or less eastward advancing of Pericarpathian Unit surpassed or left behind Paltinoasa Faults system. The interlining zones prove to be the most favourable for hydrocarbon structural traps. The vertical and the strike-slip neotectonic movements have also played an important role, horst and graben structures were created on both sides of the longitudinal faults.



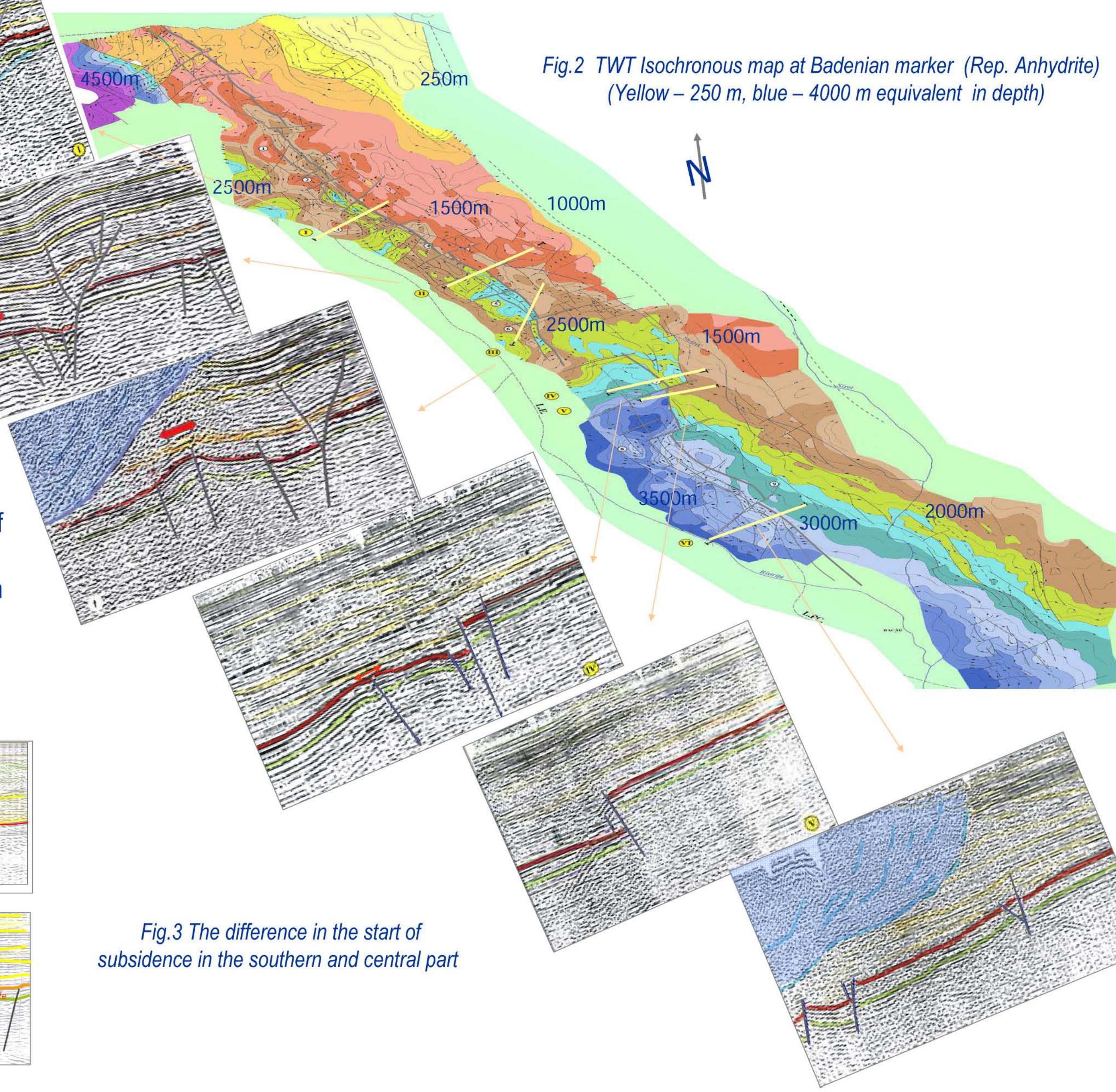


Fig.2 TWT Isochronous map at Badenian marker (Rep. Anhydrite) (Yellow – 250 m, blue – 4000 m equivalent in depth)

The subsidence was initially more active in the southern part of the region, this being demonstrated by the appearance of new stratigraphic terms just over Badenian marker, and later more active in the central part of study area, where the thickening of sedimentary pile occures in the middle part of Sarmatian. (Fig. 3)

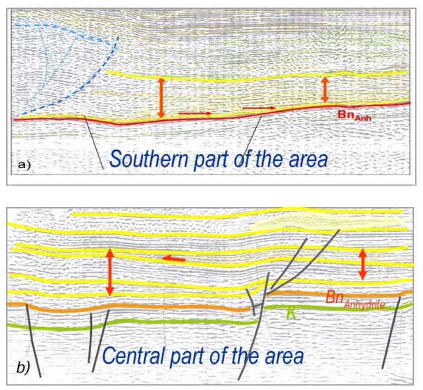


Fig.3 The difference in the start of subsidence in the southern and central part

Beginning with Alpine inversion and continuing with Neogene deformations the area manifested differences in stress and subsidence. So, different type of hydrocarbon traps has been formed:
Following a north to south succession of geological sections based on seismic profiles interpretation (Fig. 1 and Fig. 2), several aspects can be mentioned:
-The ratio at an equivalent scale between the two mechanisms responsible for the structural feature (subsidence / compression) is different from one sector to another.
-The sub-unitary values of this ratio indicate a strong, long-time compression that affected the whole sedimentary pile.
-The supra-unitary ratio indicates a distension of the western part because of a more active subsidence on certain sectors. The faults are normal and the structures are larger.

Structural traps, wide anticlines between normal faults (in the North), strong symmetric anticlines flanked by high step normal faults and roll-over on reverse faults (in Central part), and large monoclinal structures (in Southern part). Depending on the stress in the area, the faults that affect the reservoirs may be tight or not. The base Neogene tectonic style suggested by the TWT isochronous map (Fig. 2) represents an essential element in establishing the perspective structural alignments and the geometry of the main faults. Seismic data show another alignment of structures further west, under the Pericarpathian Unit, at about 3000 - 3500 m depth.
The vertical and the strike-slip neotectonic movements have also played an important role, horst and graben structures were created on both sides of the longitudinal faults.

The stratigraphic traps are present in the Sarmatian deposits. After a short break at the end of Badenian, when the Parathetys waters withdrew, the sedimentation restarted, the first deposits thickness proving a continue subsidence process but with discontinuous character. The next sediments become more complex, sand and sandstones (even oolotic limestone's), latchstring and deltaic deposits. The delta-front sandy bodies are the main objectives for biogenic gas accumulations. During Upper Sarmatia the sedimentation continued only in the southern part of the platform. Seismic images and wells correlation offered a new interpretation regarding the distribution of the productive levels. Even if the traps are litho-stratigraphic, the hydrocarbons distribution is tectonically controlled, being connected with the westwards descending, gravity collapse and pinch-outs within each step.

For Paleozoic and Mesozoic formations, protection disruption has influenced the preservation. And that, because the major tectonic events that have controlled the structural evolution. Alpine inversion had a negative impact; the Neogene development had a positive one.

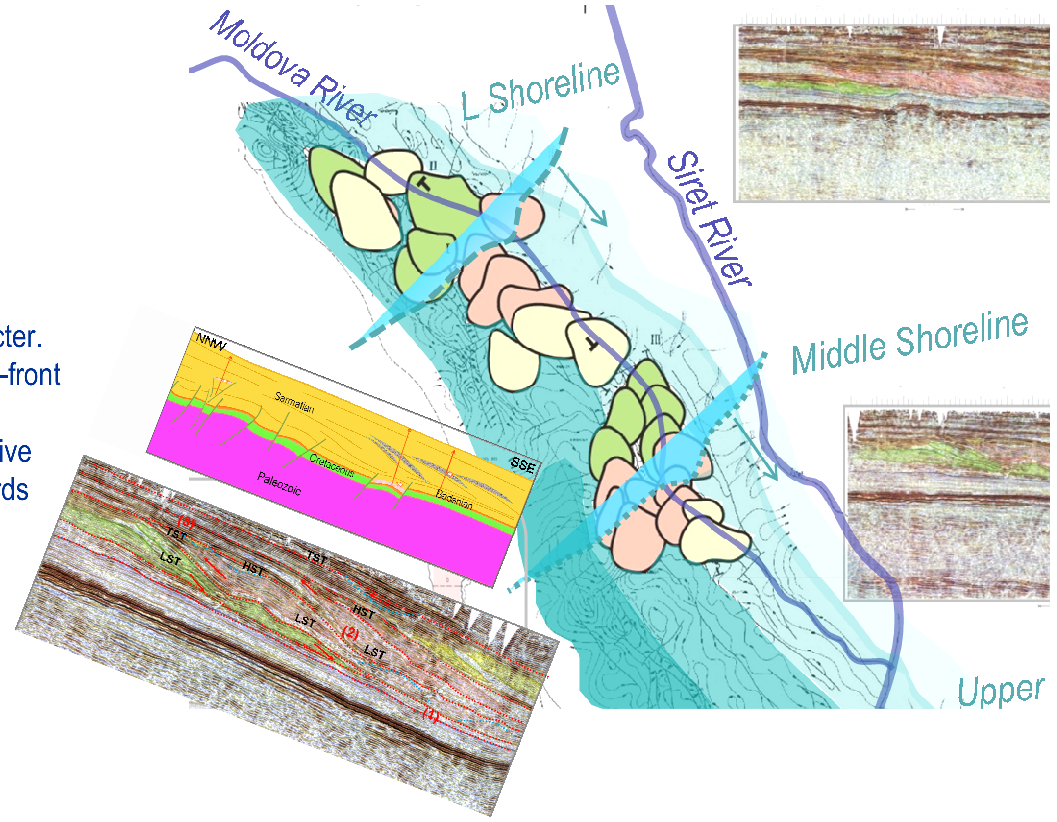


Fig.4. Paleo-Moldova River deltaic complex.

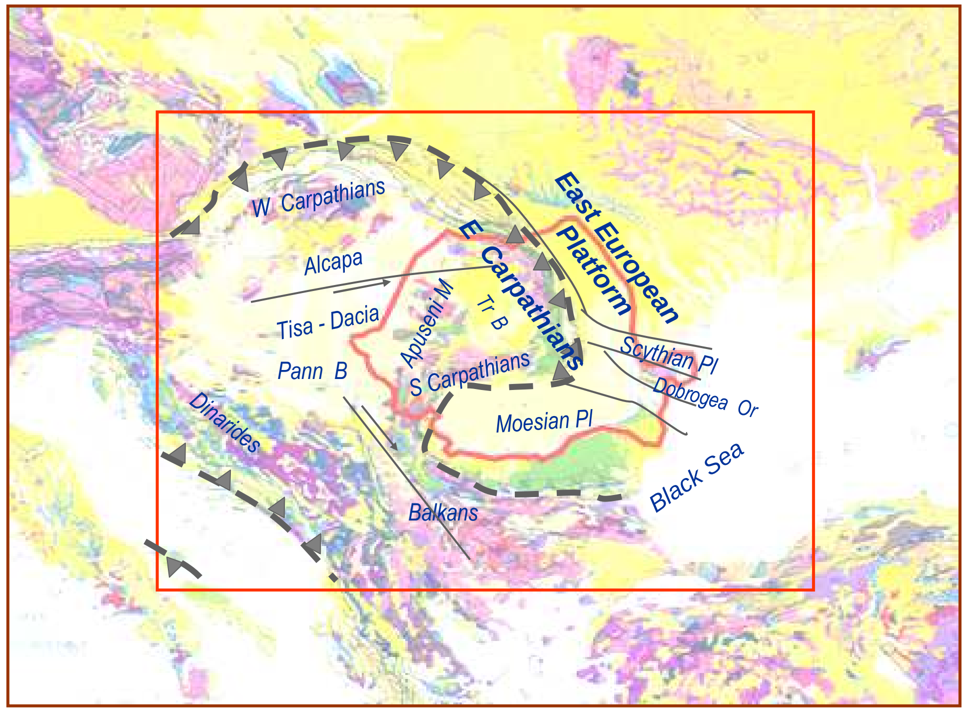


Fig.6 Tectonic units in the Eastern Carpathian area; plates position and thrusting zones (dash arrow lines).

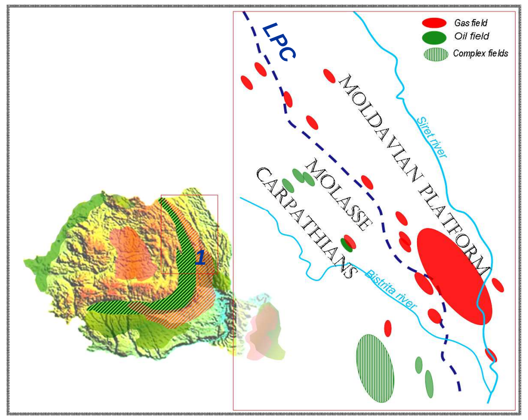


Fig.5. Moldavian Platform/Outer Carpathians oil & gas fields. (1-Mio/Pliocene Pericarpathians PS LPC-Pericarpathian Line)

Conclusions

- The presence of the hydrocarbons in this area is the result of sedimentary basin dynamics and of the association in a certain manner of the reservoir, source and seals.

-The main moments of Pre-Alpine, Alpine or Neogene tectonic inversion were important in hydrocarbon preservation and distribution.

-Differences in compressional stress and subsidence along East Carpathians front line and their Foreland created different kind of possible hydrocarbon structures.

-The cross faults (West-East oriented) have also played an important role in separating different blocks. Thus, a veritable chain of uplifting and downgoing that follow the longitudinal faults trail has been formed

-The relationship between Pericarpathian Line and the main Foreland System Faults determined the type and the magnitude of the structural elements.

-The next important step is represented by the analysis of preferential migration ways from Oligocene/Miocene sources of the flysch area to the foreland structures.

- Paleozoic source/reservoirs rocks for unconventional accumulation, must by analyzed in tectonic evolution context that influenced maturity and preservation.

- High resolution seismic records for deeper area and complex tectonics are very important.

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