ABSTRACT

In the study "*The impications of belts overthrust from subasment of Comănești sedimentary basin in hydrocarbons generation*" we plan to address the issues related to generation of hydrocarbons in the nappes of the External Flysch Carpathians in terms of heat input of overthrust in the maturation oligocene source rocks of Vrancea unit.

The researches has been materialized in a complexe one-dimensioned analyses wich assumed the study of the burial history, the analyze of the thermic regime and also the analyze of the characteristic parameters (conductivity, capacity and thermal diffusivity) and modelation of termic evolution of oligocene source rocks, with quatification of the termic apport of overthrust.

The target area from the study corresponds to the petroleum structural assembly Comăneşti-Podei-Şipoteni, perimeter that fits, in terms of geographical position, in central area of Comăneşti sedimentary basins.

In the first chapter - THE HISTORY OF RESEARCHES we have briefly summarized studies both nationally and internationally on the issue of hydrocarbon generation in overthrust areas.

If international undertaken researches since the early 80s gave good results and proposed thermal models were applied and further developed, on the external flysch Carpathians nappes were expressed only some suggestion of overthrust Tarcău nappe was the trigger factor of maturation of source rocks and default nappe Vrancea hydrocarbon generation and expulsion by them.

The first models developed belonged to Angevine and Turcotte (1983) and Furlong and Edman (1984). These models have been proposed for the realization of one-dimensional modeling of the evolution and maturation consisted of combining thermal effect of overthrust with thermal maturation charts Lopatin-Waples.

Subsequent applications of these models were made especially for the source rocks of the blaids of the Wyoming-Idaho-Utah region (USA) and by other researchers.

In Europe, despite concerns this starts a little later, research in the French Institute of Petroleum (and others) have resulted in the development

of a two-dimensional numerical model of thermal source rock evolution; this model takes into account the kinetic evolution of nappes in the basin.

In Romania, the main works that refer to the implications of the Carpathians overthrust nappes on generating hydrocarbons belong to Stanescu and Morariu (1986), Dicea *et al*. (1991), Vodă and Vodă (1992), Caminschi *et al*. (1998), Pandele and Stanescu (2001) and Grasu *et al*. (2007), but none of these works does not apply a thermal model to quantify the contribution of overthrust.

Chapter 2 - THE NATURAL SETTING appealing to an extended bibliography I made a presentation of the area of interest in terms of its geographical and geological characteristics.

Thus, after the geographical and geomorphological features, boundaries and river network in subchapter 2.1, the next chapter was devoted to the exposure of the main geological features of the region by addressing the following topics: the evolving nature of the Carpathians, lithostratigraphic main structural and tectonic units of the region.

After the relatations about the development of Eastern Carpathians I made a presentation of the litostratigraphy component parties in the two nappes and of the Comăneşti post-tectonic basin.

Chapter 2 ends with the main aspects of the tectonic nature.

As tectonic evolution, major events (deformation, uplift and erosion) that determined the current structural arrangement of the area studied were related to the location of the overthrust nappes of Tarcău and Vrancea units. This location was carried out in two stages (Săndulescu, 1984). First held on the basis of primary separation units and such, then realizing overthrust itself.

After lifting and erosion of nappe take place the formation of Comăneşti Bassin, probably after the pattern of distension of the lystric faults (Grasu et al., 2004).

Chapter 3 - OIL SYSTEMS UNDER EXTERNAL FLYSCH OF EASTERN CARPATHIANS. Since approaching the relationship between source rocks and hydrocarbons within a sedimentary basin can be made only within the context of petroleum, in this chapter we have developed a description of the petroleum system components and related processes, with examples of overthrust them for external flysch nappes in the

Carpathians. We also summarized the main distribution structures and oil provinces in this unit orogen.

The composition of an oil system take part two subsystems: one generation-expulsion (which identifies the source rocks) and other migration-accumulation (with role in directing hydrocarbons expelled from the source rocks in areas where they are accumulated and preserved).

For Vrancea and Tarcău nappes was presented a synthesis of all these components and related processes (after Ștefănescu *et al*., 2005). Proven source rocks in both units are oligo-miocene pelites within shale sequences (menilites and bituminous marls, lower dysodilic shales, upper dysodilic shales). Dominant traps for these units are the structural ones.

Regarding Comăneşti Basin, this unit has no hydrocarbon source rocks due to unfavorable conditions in the moment of sedimentation, accumulation of hydrocarbons (migrated from subjacent units of flysch) realised in some lithologic and stratigraphic types traps.

Oil structures identified were separated into two main areas by Pandele and Stănescu (2001) depending on the particular geological and petroleum related habitat.

Chapter 4 – COMĂNEȘTI-PODEI-ȘIPOTENI OIL STRUCTURE presents a detailed description of aspects of geology and hydrocarbon generation in the structure chosen for the study case.

In this chapter we provided some information about the location and geographical classification of this structure, specific lithostratigraphic, structural and tectonic features.

Unlike the general profile within this structure Comăneşti Basin unit is represented only by the Sarmatian formations (Dofteana and Şupanu). Also, Tarcău nappe has suffered differentiated erosion at the borderline with Comăneşti Basin, being intercepted in probes both Oligocene and Eocene formations. This was highlighted by three-dimensional representation of the structure on the edge of cover (Comăneşti Basin) and ground (Tarcău nappe).

From the structural point of view, all in the form of an asymmetric anticline discharged eastward, divided into a number of tectonic blocks separated by a longitudinal (sealed) and transverse (communicating) fault system.

Regarding the presence of hydrocarbons, Comăneşti-Podei-Şipoteni is the only structure in which accumulations were identified in all three units: Vrancea Nappe, Tarcău Nappe and Comăneşti Basin. Hydrocarbon source rocks of these units are considered oligocene pelites from the Vrancea nappe.

In the end of chapter were presented lithological column and features open formations in Şipoteni S300 well, one that focused on practical applications and modeling realised in next Chapters.

Chapter 5 - BURIAL HISTORY OF SEDIMENTS. The objective of this chapter was to represent the evolution of source rocks in the content of Vrancea nappe in geological time. In this sense, the reference in the modeling unit, we chose bituminous marls formation, which is located in the basal unit of the suite of oligocene rocks rich in organic matter.

Burial history modeling is the process by which the restoration thickness geological formations at the time of their sedimentation in sedimentary basin.

To achieve the burial curve of the chosen structure it was necessary as a reference sediment, the decompactation of the sediments and for this purpose we used the method called "backstripping" (Watts and Ryan, 1976).

In order to restore the original thickness of the formations was necessary to know the law of variation of porosity with depth for the lithologic types encountered in these formations. In this respect, using the compaction model proposed by Athy (1930) and based on the values of porosity resulting from the interpretation of logs for real resistivity determination for different wells drilled in the structure, we obtained surface porosity and compaction factor of the main types of rocks (shales and sandstones) encountered in the sedimentary column of S300 well.

Previously of backstripping analysis, the column was separated into eleven units; of nine lithological formations and two erosion hiatuses. The ages of units were assessed by recent research, using the stratigraphic scheme of Paratethys while estimating the thickness removed hiatus units was achieved by reference to the structure or the whole basin scale.

Further, the backstripping process involved the restoration of thickness units within stack of the sediments during basin evolution through progressive removal of formations. To achieve this stage we used a computer program developed in the Department of Geology of the University "Alexandru Ioan Cuza" in Turbo Basic language, a program that is based on the general equation of decompactation (Angevine *et al*., 1993).

Input data and parameters used in the calculation program for restoring original thickness were formed from: number of lithological units (including hiatuses), actual depth to the base and top of each units, initial surface porosity, compaction coefficient and density of mineral matrix.

Values of surface porosity, compaction coefficient and matrix mineral density for each part separately were calculated as the arithmetic mean of the values of these parameters weighted by volume fraction of each type of rocks from lithologic formations.

After running the program I got decompacted depths, thickness and porosity for units in each stages of burial. For a better understanding of the evolution, the results were summarized in the backstripping diagram.

The chapter concludes with a comparative plot betwen actual and decompacted thickness curves for burial hystory of bituminous marls formation.

Decompacted curves of bituminous marls formation and the upper formations of sedimentary column (from S300 well) includes both periods of subsidence and the period when basin stage was raised and eroded.

Chapter 6 – EVALUATION OF THE IMPORTANCE OF THE THERMAL REGIME present importance of thermal regime of a sedimentary basin for petroleum potential and the obtained results from determined thermal parameters of rocks under conditions of uncertainty for S300 well sedimentary column.

Analyzing the equation for conduction under non-stationary thermal field were established main parameters that influence the thermal regime: geothermal gradient, thermal diffusivity, conductivity, specific heat and density of rocks.

Methodology for determining these parameters is complex and quite difficult especially when they are not available in situ or laboratory measurements.

Geothermal gradient of Comăneşti-Podei-Şipoteni oil structure was established based on temperatures recorded at different depths in several wells drilled in this area.

Other thermal parameters (thermal conductivity, density and specific heat) were estimated under uncertainty, according to the methodology. Thus, we applied a series of temperature correction for in situ conditions.

These corrections were made based on the methodology presented in the literature and the temperatures were considered for each unit (formation) in part, according to the geothermal gradient. After researches I found that these corrections produce a particular change in the values of thermal conductivity for formations placed in more depth, other parameters had some minor changes of values after corrections.

Thermal diffusivity was calculated as the ratio between conductivity and heat capacity.

The novelty we bring by realizing this chapter is to apply the backstripping analysis procedure inn case of thermal regime, thus obtaining parameter values for both the current and decompacted column open in well S300.

Following the calculations and corrections I could highlight parameter variations with time and depth of burial.

The results revealed an average thermal diffusivity of the sediment column of $5.67 \cdot 10^{-3}$ cm^2/s. This value can be compared to the average thermal diffusivity value for the first 50 km of the lithosphere Earth ($6 \cdot 10^{-3}$ cm^2/s - Airinei, 1987).

However, in literature, for potential hydrocarbon areas affected by thrusting (eg. Wyoming Basin - USA) was used for thermal diffusivity a value of $5 \cdot 10^{-3}$ cm^2/s (Angevine and Turcotte, 1983), the amount otherwise close to that obtained by us in this paper for sedimentary column opened in S300 well.

Chapter 7 – MODELATION OF SOURCE ROCKS THERMAL EVOLUTION AND OVERTHRUST IMPLICATIONS representing the most important chapter of the thesis and presents simulations and undertaken modelings (S300 well) as well the results obtained to develop a response in terms of implications for hydrocarbon generation in overthrust area of the structure.

Maturation of source rocks in a basin and the transformation of organic matter into hydrocarbon requires formation burial in geological time and create necesary temperature conditions. In other words, the main parameters governing the evolution of source rocks in a basin are time and temperature. Therefore, achieving thermal evolution model for hydrocarbon source rocks (eg. bituminous marls formation) of the contents of Vrancea Nappe we used both the results obtained in the chapter on burial history of the basin formations and these resulting from evolution of the thermal regime simulation for the sedimentary column S300 well, in current conditions and in geologic time.

One of the most popular methods for simulation of organic matter maturation from source rocks is the model of time-temperature index (Lopatin-Waples), model used in this chapter to assess the maturation of bituminous marls formation (well S300) . The method was applied for the period before overthrust, when the thermal regime has not changed. Thermal gradient was held constant and temperature isolines were superimposed over the burial curve profile of merker formation in order to perform calculations.

For the post-overthrust period was applied a model (Angevine and Turcotte, 1983) that combines Lopatin-Waples method with thermal effects of overthrust. Thus, taking into account the thermal effect, the temperature isolines have undergone important changes at this stage especially in the first million years after the overthrust.

The results of this model showed that source rocks opened in Şipoteni S300 well did not produce oil until now, being in submature stage, with a time-temperature index lower but close enough to 15, the corresponding value to debut generation (Waples, 1980). The researches found that although places overthrust formations with temperatures favorable source rock maturation, generation did not occur immediately after the overthrust as the time was not enough.

CONCLUSIONS

The main conclusions that can be drawn from the implementation of this PhD thesis are:

- As a result of the variation of the porosity with depth modeling revealed a surface porosity of 62% for shales and 38% for sandstones. Compared with the values given in the literature, the surface porosity of the shales is very close to it. In contrast, surface porosity of sandstone has a lower value, something that could be attributed to lateral compressions that affected nappes during overthrust.
- Decompacted burial curve representation of the bituminous marls formation permitted revealed periods of subsidence, uplift and erosion over geological time, periods that have influenced the source rocks thermal evolution.
- Erosional hiatuses that affected all three structural units were approximated as having a minimum aggregate thickness of about 3000 m, aspect which favored slowing maturation rate of source rocks.
- By correlating the recorded temperatures at different depths in boreholes revealed a geothermal gradient of 2.81 °C/km for Comăneşti-Podei-Şipoteni structure.
- The thermal regime characterization of a region can be performed in an indirect way, under conditions of uncertainty, when are not available measurements of thermal parameters (in situ or laboratory) for analyzed basin.
- Backstripping analysis allowed estimation of thermal parameters (conductivity, capacity and thermal diffusivity) for both the current and in geological time sedimentary column.
- Average thermal diffusivity obtained for the lithological column of well S300 ($5.67 \cdot 10^{-3}$ cm^2/s) is comparable to both the average value of the same parameter for the first 50 km of the lithosphere and the value used in other basins affected by the thrusting.
- When determining the thermal parameters of rocks under conditions of uncertainty is necessary to apply temperature corrections to in situ conditions. The analysis in this paper indicates that notable changes after applying these corrections

occur on thermal conductivity, in particular in the buried lithological column.

- Time-temperature index value for bituminous marls formation after taking into account the thermal effect caused by overthrust indicates that the source rock is submatur stage.
- As the results indicate that the source rocks of Comăneşti-Podei-Şipoteni structure have not generated hydrocarbons, most likely, accumulation from the structure collectors originate from their migration from areas where source rocks were buried to greather depths.
- The results obtained can give an answer that although source rocks are oligocene, main accumulations are concentrated in Eocene of TarcăuNappe and Sarmatian of Comăneşti Basin.
- Simulation of thermal evolution of source rocks by incorporating thermal contribution of overthrust indicates that in the case of Comăneşti-Podei-Şipoteni structure, it had no role in the maturation process because the time for the temperatures that were brought source rocks from overthrust was too short.
- Instead, we believe that overthrust favored the formation of traps and hydrocarbon migration through the development compressions and fault systems.
- Since Tarcău Nappe thickness increases from east to west is possible that in other areas overthrusting have favored the generation of hydrocarbons from source rocks within the Oligocene of Vrancea Nappe. In this sense, we consider necessary and appropriate to achieve a comprehensive two-dimensional analysis of directional E-V that consider overthrust heat input at different rates of advancement of the nappe. Such a model could highlight trends in the degree of maturation in the transverse direction of the nappes.
- Linking simulation models of thermal evolution of source rocks with the results of geochemical analysis of total organic carbon or other analysis (vitrinite reflectance, thermal alteration index) would provide a higher degree of certainty.