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Shale Gas Resources in Pucioasa Oligocene Formation

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Abstract

The last decade marked an important step forward in "shale gas" exploitation all over the world. According with it we tried to emphasis new opportunities of these achievements on Romania's territory. The Pucioasa Oligocene formation is characterized by thick shale layers alternate (interbedded) with thin (micro)sandstone layers. Their total thickness (apparent) may rich more than 1500 m and has a relatively large area of development in the north-west part of the Miopliocene Zone of Muntenia. Wells drilled in this formation encountered many difficulties because of the gas content of these shally layers. Calculating the petroliferous potential of these layers (considered as source rocks) we realized the possibility to initiate an evaluation of gas potential which proved to be promising. The main characteristic of these layers (concerning exploitation possibilities), overpressures, etc., provided fruitful conditions for this attempt. Based on these assumptions, correlated with gas potential calculations we concluded that this formation (Pucioasa Oligocene layers) represent an alternative for gas producing zones of Romania.

Key words: *shale gas, generation, overpressure, source rock, reservoir rock, wells.*

Introduction

In the last years the gas production capacity of Romania decreased so only a part of the consume necessities both industrial and domestic have to be completed with important gas amounts from abroad mainly from Russia. The perspectives for new "classic" gas resources are at least minimal so an additional gas source is very desirable for the country. One of the relatively recent developments in this domain refers to the so cold shale gas resources and adequate technologies have been obtained for this unconventional "reservoir" type and its exploitation. The main characteristic of these reservoirs consists of a very small "porosity" practically very low under the usual values (a normal reservoir rock has at least 7% porosity) and also we may emphasize a few to no fissures in these rocks due to their plastic behavior.

The good results obtained all over the world encouraging us we tried to identify shale reservoirs in Romania and also we try to predict their gas generative and productive potential which correlated with their mechanical properties make them able to become important and relatively accessible sources for gas exploitation in economical conditions.

General Geologic Frame

Mainly a shale gas formation is characterized by the next important features:

- shale/marls lithology,

- interbeded porous intercalations able to develop fissure systems,
- gas generating conditions,
- important rock volumes

which made them interesting from an economical point of view.

As we know Romania's teritory is divided in more tectonic units (fig. 1) each of them characterized by specific conditions regarding hydrocarbons generating [2] and accumulating potential. Excepting the crystalline outcropped zones almost all tectonic units [7] contains more or less thick pellitic sedimentary series but not all of them are accomplishing the conditions mentioned before. Analyzing each unit we concluded that, for a better approach, Tarcau nappe unit, and mainly Pucioasa oilgocene formation represents a good choice providing the necessary conditions for such an attempt. The reasons for this selection will be exposed in the chapters bellow.

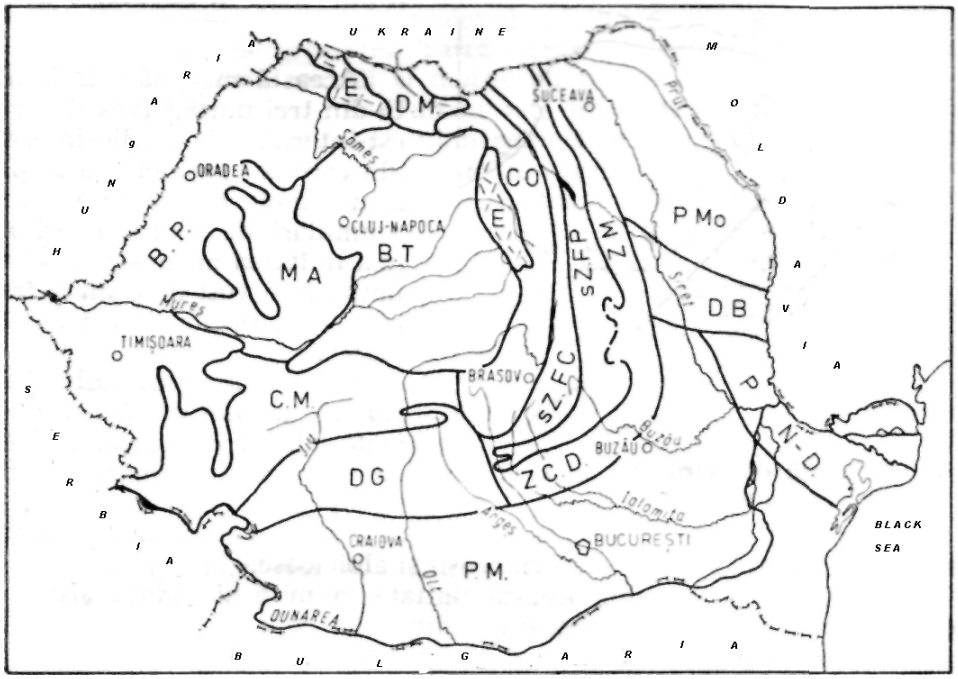

Fig. 1. Romania's main geological units: P.Mo. – Moldavian Platform, D.B. – Barlad Depression, P.N.D. – nord-Dobrudja, P.M. – Moesian Platform, E. – Neogene Volcanic Chain, C.O. – Oriental Carpathians, C.M. Southern Carpathians, M.A. – Western Carpathians, Z.F.C. – Inner, Cretaceous, Flisch, sZ.F.P. – Outer, Paleogene, Flisch, Z.C.D. – Diapiric Folds Zone, D.G. – Getic Depression, B.P. – Pannonian Basin (Romanian area), B.T. – Transilvanian Basin, D.M. – Maramures Depression [2].

Pucioasa Oligocene Formation Characterization

Pucioasa formation is placed in the south –west part of Tarcau unit and it represents the main series of the Oligocene deposits from the western termination of Tarcau nappe [5]. It has a variable thickness from 500 to 1000m restricting towards east. It is divided in 3 important levels:

- Lower level consisting of marls with disodilic aspect, black to grey colored, and episodic sideritic limestones,
- Medium level consisting of calcareous sandstones, the so called Fusaru sandstones,
- Upper level, similar with the lower one, consisting of marls with interbeded disodilic schists.

Formed mainly of pellitic rocks Pucioasa – Fusaru lithofacies emphasize a pronounced rithmic gradding of sediments, consisting of pelagic and hemipelagic shales, bituminous interbeded with fine and/or siltic sandstones. Towards its upper part due to the increasing of calcium carbonate content shales are replaced by marls.

The depositional system is a deep sea type, with very fine sediments, very thick, with dominant pelagic and hemipelagic sequences.

The tectono-sedimentary evolution of Pucioasa formation is dominated by a very fast subsidence, more than 150 m/M.Y. so the studied deposits reached 5000 to 6000 m depth in a relatively early stage.

As a consequence the fluids expelling processes were very slow or even ceased. In this conditions the pressure gradients of the whole Pucioasa formation are very high up to 0.19 – 0.195 barr/m. In these conditions we may say that all the shales and marls of the series are under-compacted. The pressure gradients mentioned before are calculated from well data and mechanical cores analysis [1]. So shale density at more than 3000m was about 2.25 grams on cubic centimeter showing an important under-compaction. Corroborated well data and seismic profiles permitted mapping the over-pressured Oligocene Pucioasa formation delineation as is shown in the figure bellow (fig. 2).

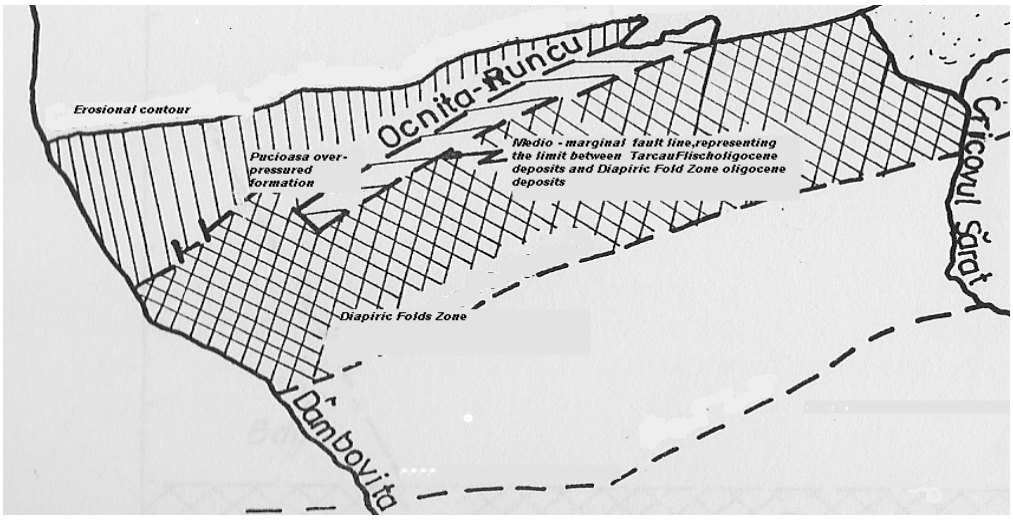

Fig. 2. Pucioasa over-pressured Oligocene formation delineation [1].

The organic matter content emphasized by the rare mechanical cores that are available from the wells indicated high values, more than 1-1.5% total organic carbon, in the actual rocks samples enough to represent a potential source rock.

Because the fluids remained in the shale formation and they subsided at more than 5000m depth even with a normal temperature gradient as were measured in the wells the formation entered into oil window and even were overcooked producing important amounts hydrocarbon. Calculation of TTI values on this scenario [1] are about 80 units. Based on the previous exposed data we estimated a hydrocarbons potential of 3 mg on one gram [9,10] of source rock.

Correlating this value with formation surface and thickness the total amount of hydrocarbons generated by this formation is about one billion tones of hydrocarbons.

Making the general assumptions of hydrocarbon migration and accumulation model we may predict the existence of more than 100 million tones of hydrocarbons in the potential existing or not yet discovered oil/gas fields.

There is an important question mark regarding the migration possibilities from source rock to the reservoir. This is provided by the too high pressure gradients of the formation. Usually they are blocking the fluids circulation so a greater amount of hydrocarbons remained in the pelitic source rock.

Shale Gas Exploitation Possibilities

Producing gas from shale formations is conditioned by the capability of the used technology to develop a communicating fissures system into the formation keeping them open and extract the existing gas reserves. The main approach for this propose is hydraulic fracturing. It is applied in many cases and provides good results.As we shown before the formation is over-pressured and shales have a relative good plasticity so there is a chance that the fissures will close very fast so we cannot produce the expected gases or we produce them only for a short time.

Fortunately the shale formation has a fraction of alternating micro, siltic sandstones usually with centimetric thickness. They are well cemented and competent rocks with a clastic behavior when a force is applied. Their reservoir character was verified during the drilling of the wells(as an example well 103 Glodeni) when during the drilling operations at the opening of Pucioasa formation we encountered frequent gas shows that forced us to work with very dense mud until 2.2 grams on cubic centimeter.

In these conditions hydraulic fracturing technologies has a good opportunity to provide a fissure system which will promote gas flow towards borehole. Analyzing the well log data we may observe that the interbeded lithologies, alternance of shale and micro –sandstones has a high frequency so even the ratio between sandstones and shales thickness is about 1 to 8 or even lower the existence of the clastic behavior rocks [6] will enhance the fissure effect of the hydraulic fracture results in order to prevent fracture closing in the plastic behavior rocks as shale and marls, especially when they are over-pressured.

Calculating hydraulic pressure for fracture [3] is a relatively easy task as long as we have formation pressure and fracture gradients values calculated from well loss. As we mentioned the pressure gradient calculated for Oligocene Pucioasa Formation is about 0.19 – 0.195 barr/m in the west part [8] of the studied area (Glodeni structure) and decrease until 0.165 towards east (Varfuri – Visinesti structures). The fracture gradient as a function of lithostatic and pressure gradients, calculated by Ben Eaton formula (the most suitable taking into account sedimentary basin type and conditions) is about 0.205 to 0.21 barr/m and can be related with the depth of the formation (between 1000 and 4000 m). Also the existence of the Fusaru sandstones level at the middle part of the Pucioasa Formation increase the possibilities of a promising gas production in the studied area.

Production Expectations

As we mentioned before an important amount of hydrocarbons was generated by the Pucioasa Oligocene Formation. From this one only about 30% or less have been expelled from the source rock which as we presented above may be turned into a “reservoir” rock. Even the producing radius of the wells is smaller than the one of a classic reservoir, speaking mainly about gases the expecting recovery factor may be estimated about 75% from the calculated resource. So the total gas producing potential may be estimated up to 50 billion cubic meters. It is obvious that

this potential refers to the entire Pucioasa formation but the exploitation must be placed on the trap zones and only there where gas migration was delayed or even stopped. So a reasonable score is about 25% of the gas potential this meaning a production of 12.5 billion cubic meters which can be obtained from Pucioasa Shale Gas Formation.

Conclusions

Pucioasa Oligocene Formation Is placed in the south west Part of Tarcau nappe and it consists of a mainly pellitic series, organized on 3 levels and has a total thickness from 1000 up to 1500 meters. During its evolution it generated important amounts of hydrocarbons, mainly gases (is an overcooked formation) but because of the rapid subsidence of the sedimentary basin expelling processes were delayed or even stopped. So Pucioasa shales remained with important gas amounts summing a reserve up to 12.5 billion cubic meters. The lithology and pressure gradients (up to 0.19 – 0.195 barr/m) of the formation [3] represent a good opportunity for hydraulic fracture operations and gas recovery.

In the actual economical frame, when Romania has to take about 35% of his gas necessities from abroad and the price is getting higher [4]exploitation of this shale gas formation resources may represent a promisefull alternative at least for a percent of the necessary gas amounts.

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Resurse de gaze in Stratele de Pucioasa oligocene

Rezumat

Stratele de Pucioasa sunt prezente in depozitele Oligocene ale Pânzei de Tărcau, mai exact in terminaţia sud-vestica a acesteia. Cu o grosime cumulativa de pana la 1500m si cu o suita pelitica in care sunt prezente intercalaţii centimetrice de microgresii bine cimentate acestea reprezintă pe de o parte principala roca sursa de hidrocarburi din pintenul de Homorâciu cât si o potenţiala zona, formaţiune de interes pentru gaze. Prin procedee moderne de fisurare hidraulica aceasta se estimează ca poate oferi o rezerva exploatabila de peste 12 miliarde metri cubi.