SHALE GAS EXPLOITATION IN THE VISION OF DIFFERENT FEATURES WITHIN EUROPE (ROMANIA) VS UNITED STATES

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ABSTRACT

In the context of growing energy demand, the need to find new conventional hydrocarbon resources and the need to emancipate from the monopoly of some countries holding such resources, the opportunity to approach unconventional hydrocarbon production seems to be crucial. The boom of unconventional hydrocarbons production started with the improvement of the technology that involves the drilling of horizontal wells with the hydraulic fracturing of particularly compact clay formations has been a major success in the United States of America.

The trend to extrapolate the advanced technology in America to other countries, there are particularities of approach, and specific conditions that differentiate Europe, implicitly Romania, from North America. To illustrate the particularities of the approach of unconventional hydrocarbons production, the paper presents some aspects regarding to the procedures necessary for the exploration, development and production of shale gas in Romania.

The paper includes assessment methodologies, characteristics of the stages of exploration, development, production and concepts of risk management which should have been assumed by the concessions agreements. Presentation of the exploration phase, with a explanation of the role of the seismic prospection and exploration well drilling is detailed, adding the implications of the need to fulfilling the minimum exploration program; the assessment parameters and their possible determinations in the cores, well diagraphies, seismic sections, sophisticated data processing are explained.

Starting from the geological setting (stratigraphy and tectonics) of the Moesian Platform which is succinctly presented, the litostratigraphy of the Dobrogea sector of this unit (East Moesia) is detailed. The presentation of the geochemical parameters of some Paleozoic formations and the assessment of some Paleozoic formations from the point of view of their unconventional hydrocarbon potential, underlying the approach evoked by the minimal exploration program for the assessment of the shale gas perspectives in South Dobrogea.

In the paper there are underlines inappropriate comparison and approach of the shale gas exploration between concessions in Europe (Romania) versus the United States of America.

Keywords: *South Dobrogea, Paleozoic formations, shale gas potential, exploration concessions, unconventional hydrocarbon resources*

INTRODUCTION

The paper presents some aspects regarding the procedures necessary for the exploration, development and production of shale gas. It includes assessment methodologies, desiderata/characteristics of the stages of exploration, development, production and notions of risk management.

Starting from the case study of some exploration perimeters in South Dobrogea (Romania), concessions awarded by Chevron in a Public Bid Call 2010, the paper shows the inconsistencies in the approach to shale gas development in Europe versus the US. Reference is made to the flexibility of the seismic prospecting in order to avoid some restrictions in the exploration stage. All considerations (assertions) highlight the need to comply with the minimal compulsory program of a concession agreement.

The paper is referring to case study of some exploration perimeters in the South Dobrogea, which were the subject of the petroleum agreements between Chevron and the National Agency of Mineral Resources. After ratification of these petroleum agreements, Chevron Romania Holding BV had should go to perform in the first stage seismic prospections and geochemical analysis, then exploration by drilling to see if there are commercial resources, and finally could go to the production stage.

SHALE GAS ASSESSMENT METHODOLOGIES

The assessment and selection of future shale formations are based on a combination of factors that includes: (1) Data, information availability; (2) Dependency on natural gas imports at country level; (3) Presence of known shale formations; (4) Observations and activities of certain companies or governments directed towards resources development. The estimate diagnosis is based on data available within specific and published literature and studies, so as to estimate the risked oil and natural gas in place resources, followed by the recoverable resource estimate of resources that are not technically proven. The methodology expresses the intent to convey the best use for some insufficient data so as to perform an initial estimate of a shale formation. The oil and gas risked in place estimates are derived from: (1) Initial estimate of in place resources volume, correlated with the task on, (2) Success factor, (3) Recovery factor for the formation of interest. [1], [2]

The implementation of such assessment includes the completion of the following specific steps: (1) Conduct a preliminary review of a basin and selection of some assessable shale formations (to be assessed); (2) Determine the areal extent of the shale formations within the basin and in addition to other necessary parameters, to especially estimate its overall thickness; (3) Determine the prospective area deemed likely to be suitable for development based on the following criteria: rock depth, quality, and the experience in application of expert judge; (4) Estimate the natural gas in-place, seen as a combination of free gas and adsorbed gas that is contained within the prospective area. The oil-in-place estimate is based on pore space oil volumes; (5) Establish and apply a composite success factor consisting of two parts: a factor of formation success probability as an indicator of how much is known or unknown about the shale formation and a success factor of prospective area as an indicator of geologic complexity and/or lack of access that could prevent portions of the prospective area from development; (6) For shale oil, it is aimed at identifying those US shales that best match the geophysical characteristics of the new formation so as to estimate the oil-in-place recovery factors (for shale gas, the recovery factor is established based on: geologic complexity; pore size; formation pressure, and clay content with implications in formations ability to be hydraulically fractured). The gas-phase of a formation includes: dry natural gas, associated natural gas, wet natural gas. Consequently, estimates of shale gas resources also include light wet hydrocarbons that are typically coproduced (associated) with natural gas. (7) Technically recoverable resources represent volumes of oil and natural gas that may be produced with current technology, regardless of oil and natural gas prices and production costs. These resources are determined by multiplying the risked oil or natural gas in-place by a recovery factor. The recovery factors of shale oil (typically lower than shale gas recovery factors, due to viscosity and capillary forces of oil) are 3-7% and exceptionally being > 10% or < 15 %. For the recovery factor, we have combined known production rates controlled by factors like: (1) mineralogy, (2) geologic complexity, (3) proper technological practices for the recovery of shale gas. [1], [2], [3], [4], [5]

There is an uncertainty level related to the extrapolation of recovery data related to the age reduced to maximum 30 years of the shale gas wells. The significant variation of shales geophysical characteristics throughout the formation and the difficulty of analogue matching with known formations, a shale formations resource potential cannot be fully determined until extensive production tests are conducted on the respective formation. It is a need to drill at least some exploration wells.

The initial assessment of shale gas resources requires the development of several stages: (1) Identify the stratigraphic sequence of potential reservoirs (especially argillites rich in organic matter) from Palaeozoic basin (pay zones); (2) Establish the surface extension of selected reservoirs and definition of prospective areas (plays); (3) Define surfaces with higher gas potential within each area (sweet spots); (4) Estimate of gas quantities in these reservoirs, which are contained in this manner (geological resource or OGIP); (5) Calculation of technically recoverable resources from the gas resource generated by the shale reservoirs. [1], [2], [5]

SOUTH DOBROGEA SHALE GAS POTENTIAL

EX-19 Adamclisi, EX-18 Vama Veche, and EX-17 Costinesti perimeters (fig. 1) are located in South-East Romania (Dobrogea region, Constanta county), being neighbored in the east by the Black Sea and in the south by the state border between Romania and Bulgaria. The above-mentioned perimeters are framed from a geologic-structural point of view in the South Dobrogea region, included in the eastern side (East Moesia) of Moesian Platform (fig. 2). Stratigraphically, the South Dobrogea region include a crystalline basement (Ovidiu group (Archaic) and Palazu group (Lower Proterozoic); followed by a poorly metamorphosed in facies of green schists = Cocosu group, Upper Proterozoic = Vendian), followed by a cover of Palaeozoic to Neozoic (4 sedimentary cycles) that has a cumulated thickness of 3,500 meters. The lithology of the Palaeozoic formations is documented based on sixteen wells that have been drilled in South Dobrogea. More interesting from the point of view of shale gas potential is Tandarei Formation = Lower clastic group (Upper Cambrian – Middle Devonian) of Middle Cambrian – Upper Carboniferous megasequence. The lower clastic group include: Cambrian-Ordovician – clastic bed formations consisting of arkosian sandstones and quartzitic sandstones with silt and silty clay intercalations (Tandarei Formation); Silurian strata consisting of clay shales with graptolites (Tandarei and Smirna Formations); Lower Devonian include quartzitic sandstones with silty clay intercalations, conglomerates, limestones (Tandarei Formation). [5], [6], [7], [8]

Fig. 1 Map showing the location of 17, 18 and 19 blocks for shale gas exploration in Romania

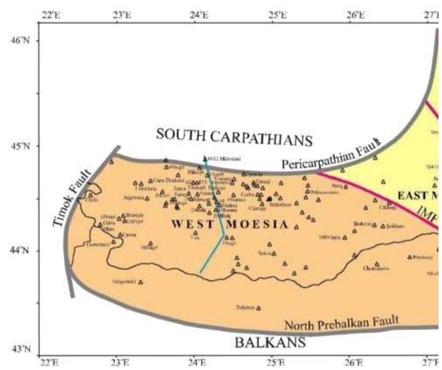

Fig. 2. Tectonic sketch of Moesian Platform with the distribution of the main wells that have crossed the Palaeozoic formations. [6]

Assessment of formations rich in organic matter of Lower Silurian – Devonian show that they have been buried deeper than the 4,000 m of Paleozoic, Mesozoic and Neozoic formations. The geochemical analysis shows TOC 0.54-4.48%; extractable organic matter = 180-2461 ppm; extractable organic matter generation index (EOM/TOC ratio) = 0.02-0.11; HC/TOC ratio= 0.01-0.06. Pyrolysis data are S1 = 0.12 mg HC / g of rock, S2 = 1.05 mg HC / g of rock; HI = 50 mg; SPI = 1 tHC / m^2, Tmax $\geq$ 500. Kerogen that based the formation of organic matter is a type II kerogen. [5], [6], [7], [8]

A proper assessment of the shale gas potential in Dobrogea is rather difficult due to the fact that existing information is scarce and poor. Moreover, the following issues need to be considered: (1) The study on the shale gas potential of East Moesia and especially Tandarei formation shows an inchoate potential of geological and engineering knowledge; (2) It is a poor knowledge of kerogen dynamics, physical properties of the rock, mineralogy and subtle changes of facies and fracking character; (3) The lack of seismic profiles of high quality; (4) Total lack or an insufficient number of wells drilled to investigate wide areas potentially hosting resources; (5) The additional effort required to reconsider: different data of palaeontology analyses (in general, poor ones), major lacks of radiometric dating, controversial aspects of absolute ages, with results in interpretation with poor basis or even forced interpretations; (6) The lack of information on: petrophysical parameters, lutites mineralogy, quartz diagenesis, facies variations, natural fracturing, thermal history and dynamics associated with kerogen maturation, pyrolysis date for the maturation models. [5], [6], [7], [8]

For the South Dobrogea region the perspective formations, which have a shale gas potential (expected from existing data and from extrapolating such data) are from Palaeozoic – Mesozoic age and they develop on large areas, and they can be found at depths of 2,500-3,000 m within the eastern side of Moesian Platform. The map of Romanian hydrocarbon fields distribution proves that the (conventional) deposits are discovered to date only west of Danube River. If the EX-17, EX-18, EX-19 exploration blocks were seismically explored, they would have been provided a continuous geological image of both sides of Danube River. All these aspects may be known by performing a detailed exploration, where several wells are drilled, allowing collecting and study of cores, and also a collection of relevant information on the existing resources and support the need to fulfill the minimum exploration program. The potential of unconventional resources in Romania, especially South Dobrogea remains to be explored.

TYPICAL FEATURES OF UNCONVENTIONAL SHALE GAS EXPLORATION IN US VS EUROPE (ROMANIA) – COMPARISON INOPPORTUNITIES

The revolution of shale gas currently in development in US was not repeated elsewhere, i.e. especially in Europe (although significant volumes of unconventional deposits are present in Poland, France, Germany, Hungary, Sweden, Turkey and UK). In order to secure expertise within the shale gas sector, several European companies have been established as joint ventures with US companies. It may be emphasized some different approaches in unconventional shale gas development between Europe and US:

1. Geology of Europe is less favorable for economic development;
2. The fiscal policy is not favorable in Europe, as opposed to the tax decreases that provided the necessary incentive in the US, which are not valid in Europe; there are differences of perceptions with respect to management and funding risks costs;
3. Onshore drilling services fewer in Europe than in the US and Europe does not have the shale gas expertise of the US operators;
4. More stringent environmental and safety regulations in Europe than the US. Also in the case of Europe and Romania, an approach oriented on legislation, regulations, restrictions and education is required;
5. Public acceptance is reduced on shale gas development and the environmental impact for Europe. The ecologic impact of hydraulic fracturing is not thoroughly assessed, except in the US;

6. The increased sensitivity of Europe than the US to the potential effect of slowing down investments in non-renewable energy sources;

7. Difference in familiarization and different education with respect to oil operations, lower in Europe than in the US. The US public is accustomed with drilling activities, considering their long history of onshore drilling;

8. Different population densities in Europe and the US: in Europe 100-200 inhabitants per km^2, higher than US average of 30 inhabitants per km^2. The shale gas potential areas in US are often located in poorly populated areas;

9. Aside from poor education on shale gas development both in Europe and Romania, it is expected to have more local opposition, due to the fact that the benefits of gas productions shall be secured by national governments and not local landlords, as it is the case in the US. In Romania, the underground is in government property;

10. Even though, after years of speculations, some progress has been recorded in developing European shale gas deposits (in more advance countries like Poland), the still is uncertainty related to the more vocal opposition of population, especially due to an insufficient communication. Moreover, there is uncertainty in Europe and in Romania related to the low geologic shale gas potential;

11. One of the reasons for which the start of shale gas production in Europe is rather slow is related to the negative impact on the environment due to the use and pollution of water, air emissions (volatile compounds, methane, and greenhouse gases), community impacts (land use, biodiversity, sound pollution, traffic). The main causes leading to consequences and risks would be: (1) development of activities within large areas; (2) geologic conditions (deep aquifers, abandoned wells, potential faults that may become pollution paths or they may result in multiple earthquakes); (3) cumulative impacts of multiple wells; (4) use of dangerous chemicals; (5) use of a large quantity of water, and some of that water would be unrecoverable; (6) volume and characteristics of wastes; (7) release of gases in the air, (8) flare burn during drilling;

12. A comparison between EX-17, EX-18, EX-19 perimeters from South Dobrogea with the large oil fields where gas is produced in the US (Marcellus, Bathrust, Barnett, Niobrara, Eagle Ford etc.), is not suitable due to the flagrant differences existing between them, as related to (1) geological conditions (depth, formation thickness, geochemical conditions, etc.), (2) technological conditions, (3) demographic conditions, (4) proximity of small or large localities, (5) the different density of wells drilled in American fields as opposed to the Romanian situation (where there are many localities with

archaeological sites, civil-military-industrial-touristic sites, among which the seaside proximity must be emphasized);

13. The infrastructure differences are also emphasized, which were also known and they should have considered them. The issue of a high-intensity approach in Europe/Romania is connected to the availability of information. It starts with geology and ends with production and economic infrastructure. Among the major differences of successful development of unconventional natural gas in the US and Europe/Romania, it must be reminded here the areas assessment, which may facilitate or not development, or they may complicate or stop such development. In the development of unconventional gas operations, groups and institutions that may have different visions on the future actions are involved;
14. There are differences on market access. The gas markets in Europe are not fully liberalized. Some members of the European community made moderate or insignificant progress towards the liberalization of the gas market. Moreover, imports of gas for EU are increasingly diversified, with a view to access prices lower than the Russian prices;
15. In Europe, there is also competition from the gas delivered through a pipeline or LNG. Recent imports of LNG in Europe at spot prices have been slightly lower than the prices of the gas delivered through pipelines based on a long-term contract. One can acknowledge that the stagnation of shale gas capitalization in Europe is an advantage on medium term for US and Canada, whose gas exports of LNG towards Europe are unavoidable;
16. If compared to US, in Europe the benefits of the shale gas appear to be rather limited due to several major issues: (1) The certain shale gas reserves are lower than initially estimated; (2) Placement on rather deeper geological layers, requiring more expensive exploration and production if compared to the more advantageous conditions in US; (3) At a high population density in Europe, the collateral damages are more threatening, and the public opposition is consequently stronger; (4) Additional infrastructure investments are necessary in some areas;
17. Even with the best political support of governments and regulating authorities, oil companies, and with the application of best practices, shale gas will not be able to change the rules of the energy game in Europe, neither the offer security, nor the reduction of emissions, however, at particular country level, the results may be remarkable, depending on the national supporting policies and depending on the reserves potential;
18. Pursuant to some representative studies, the shale gas extracted from own resources shall cover only 6-14 % of the internal need of Europe, a level that is insufficient for the liberation of Europe from the import

gas dependency. It is an argument of the will of Romanian Government to continue its task of shale gas development.

CONCLUSIONS

The methodology used to conduct the seismic prospection in South Dobrogea was a high-resolution method, based on the small distance between channels and the deep depth of investigation (6 milisec), as premises of an optimum interpretation. The fact that the entire designed profiles grid was not developed reduced the interpretation options (the assessment on the extension of the formation and the correct estimate of their thickness) with expected generation capacities. It is clear that the entire designed grid was mandatory so as to facilitate mapping of the formations both at overall and detail scales, intent clearly anticipated from the very beginning. A special and comparing processing of the seismic profiles would have led to the optimization of the formations correlating, as well as the lithofacial variations both horizontal and vertical.

With respect to the design of seismic alignments in the restricted areas (such as social sites – villages, military, industrial, civil, religious, touristic, natural protected areas, stubborn landlords refusing leasing the property), the data acquisition technology allows bypassing restriction and their mitigation. We would like to technologically stipulate the possibility of shortening the profiles, abandonment, and deviation with the risk of getting a rather poor signal, with an increased effort of seismic processing and interpretation. Another aspect would be, so as to have credibility and to complete the optimum data processing (especially in the case of a poor signal recorded due to deviation of the alignment), distribution of primary data would have been an option not to a single unit, but to several witness units for processing and interpretation. Efforts could have been made from social and bureaucratic points of view to increase the price of leasing from small landlords or more effort in securing the permits faster. As to the early statements of the investor, one can see an inconsistency recorded in time, as the desire for communication and follow-up on works dropped.

Any interpretation and assessment of the petroleum potential (both conventional and unconventional) are not feasible due to the lack of the entire seismic grid that was proposed and designed during the preliminary stage, pursuant to the minimal schedule, and due to the lack of exploration wells. We need to emphasize the need to drilling wells both for securing core data and well geophysics data, but also for the calibration opportunities of the data secured from geophysics extrapolations. Meeting the proposals included in the minimum exploration program, as provided in the oil agreements, appears to be a mandatory duty for the Romanian government as related to the minimal information of the explored areas, with a view on the presence or absence of potential for mineral resources and their conditions (both geologic and economic).

To conclude, the areas with restrictive access may, theoretically, produce certain discomforts for the exploration and production activities (the activities cannot be scheduled as easily as in the case of vacant areas, with no economic activity), but these are well-known and are somehow considered upon participating in the leasing bidding (as it is the case in most of the countries where such activities are being developed) and it does not have a major impact on the timely development of exploration activity and in the end on the production activity. Moreover, for a better knowledge of existing resources it is critical to complete the mandatory minimal schedule, a schedule that in this case could have been completed, the issues faced being rather normal in such cases and could have been addressed with a rather minimum effort.

REFERENCES

[1] Alexander, T. et al., Shale Gas Revolution, Oilfield Review, 23, no. 3, pp. 40-55, Schlumberger, 2011.

[2] Lewis, R. et al., New Evaluation Techniques for Gas Shale Reservoirs, Reservoir Symposium 2004, Schlumberger, 2004.

[3] U.S. Energy Information Administration (EIA), Technically Recoverable Shale Oil and Shale Gas Resources: Other Eastern Europe, Washinton D.C., 2015

[4] Cranganu, C., Gazele de sist si fracturarea hidraulica, intre mit si realitate, Editura Integral, Bucuresti, 2014.

[5] Frunzescu, D., Exploatarea resurselor neconventionale de hidrocarburi in perspectiva diferentelor de conditii dintre Romania (Europa) versus SUA. Studiu de caz: Dobrogea de Sud, Editura Universitatii Petrol-Gaze din Ploiesti, 140 p., 2018

[6] Seghedi, A., Paleozoic formations from Dobrogea and pre-Dobrogea – an overwiew, Turkish Journal of Earth Sciences, Vol. 21, pp. 669-721, 2012.

[7] Anastasiu, N., Branzila, M., Seghedi, A., Tabara, D., Sedimentary formations in the Carpathian foreland shale gas potential, National Conference of Geological Society of Romania, December 18th 2013, Conference Proceedings, pp. 3-7, Ploiesti, 2013.

[8] Popescu, B.M., Veliciu, S., Tandarei and Radauti Formations: Future Unconventional Exploration Gas Plays in Romania, Search & Discovery Article #80369 (2014), AAPG Europe Regional Conference, Tbilisi, Georgia, 26-27 September 2013.