THE ENERGY POTENTIAL OF NATURAL GAS FIELDS FROM TRANSYLVANIAN BASIN

Current and Future Trends

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Abstract: Transylvanian Basin is one of the most important natural gas basins in Continental Europe that marked the beginning of the development of the natural gas industry in Romania by the discovery of the first natural gas field in 1909 in Sarmasel (Mures County). The Basin of Transylvania is the geological unit with the largest and most natural gas reservoirs in Romania. It is the single sedimentation basin in Romania and among the few in the world where only gas accumulations, mainly methane, have been discovered, to which are added very small proportions (below 2%) of higher fractions (in the south-east area of the basin).

Keywords: Natural gas basin, methan, Transylvanian Basin

Rezumat: Bazinul Transilvaniei este unul dintre cele mai importante bazine de gaze naturale din Europa continentală care a marcat începutul dezvoltării industriei gazelor naturale în România prin descoperirea primului câmp de gaze naturale în 1909 în Sarmasel (judetul Mureș). Bazinul Transilvaniei este unitatea geologică cu cele mai mari și multe rezervoare de gaze naturale din România. Este bazinul de sedimentare unic din România și dintre puținele din lume în care au fost descoperite doar acumulări de gaze, în principal metan, cărora li se adaugă proporții foarte mici (sub 2%) de fracții mai mari (în zona de sud-est a bazinului).

Cuvinte cheie: Bazin de gaze naturale, metan, Bazinul Transilvaniei

INTRODUCTION

Transylvanian Basin is one of the most important natural gas basins in Continental Europe that marked the beginning of the development of the natural gas industry in Romania by the discovery of the first natural gas field in 1909 in Sarmasel (Mures County).

The Basin of Transylvania is the geological unit with the largest and most natural gas reservoirs in Romania. It is the single sedimentation basin in Romania and among the few in the world where only gas accumulations, mainly methane, have been discovered, to which are added very small proportions (below 2%) of higher fractions (in the south-east area of the basin).
The largest and the important gas reservoirs were discovered and put into operation until 1980s, reaching a peak point production in 1976. Since 1976, the dynamics of annual gas production in the Transylvanian Basin had a downward trend, more pronounced since 1988.

In Transylvanian Basin were discovered important reservoirs of natural gas above the Badenian salt horizon, which extends almost like a continuous plate all over the basin.

The fields discovered so far belong to the three stratigraphic sequences above the horizon of the salt (Badenian, Buglovian and Sarmatian) whose thickness varies between 300-1500m and extend along the whole surface of the basin.

THE NATURAL GAS RESERVOIRS FROM TRANSYLVANIAN BASIN

In the Transylvanian Depression, were identified more than 100 gas structures (the post-saline sedimentary sequence) and the exploration activity of the three blocks (RG01 - Transylvania North, RG02 - Transylvania Sud and RG03 - Transylvania South) continued with the development and the exploitation of commercial natural gas reservoirs.

Currently, the commercial gas reservoirs are divided in three groups being delimited by Tarnava Mica and Mures rivers (see Fig.2).

North Group contains 31 natural gas fields located above the Mures river. These are found under the form of dome traps. For example, Sarmasel is the first gas reservoir discovered in Romania by drilling the well #2 and put into production in 1909. Representative gas reservoirs for north group are also Grebenis field, Zau field, Taga field but not limited.
Central Group is delimited between the Mures and Tarnava Mica rivers and contains 19 gas fields. Within this “corridor” are located important gas fields such as Mures, Corunca Sud si Nord, Acatari, Ernei etc.

South Group is located on the south part of Tarnava Mica river, it contains 53 gas fields, among which are the major structures such as Delenii (1916), Filitelnic-called also the “Queen of the Basin”, but also structures such as Nades –Prod, Laslau Mare, Sadinca, Tauni and others whose natural gas production is significant.

THE CURRENT ENERGY STATE OF THE NATURAL GAS FIELDS IN THE TRANSylvanian BASIN

Research works on the discovery of natural gas reservoirs over time through drilling and seismic prospecting at high deep depths has led to many useful data on estimating the energy potential of the Transylvanian Basin. The Transylvanian Basin is ranked on the 56th place in the world in size and own 0.2% of the world's gas resources (according to a report published by USGS World Energy).

Fig. 2. Approximate location of the gas reservoirs located in Transylvanian Basin.
More than 4,000 wells were drilled over the time in Transylvania depression (of which approximately 2200 exploration wells) whose average depth is approx. 2500-3000m, the vast majority of them having as target the productive geological formations located above the salt horizon.

Although it is a technical and financial challenge, a significant number of 94 wells have crossed the salt and such examples are well 6042 Delenii (5062 m), well 4502 Filitelnic (4533 m), well 4501 Band (4505 m), well 4 Mica (4015 m) and well 4843 Mociu (4001 m).

The reservoirs from Transylvanian Basin were discovered and put into operation until the ‘80s and due to the economic and social development considerations of Romania they were often exploited in an intensive regime reaching today an advanced stage of depletion falling into the category of mature fields or brown fields.

The recovery factor is the key performance indicator to evaluate the current state of energy of the gas reservoirs. The recovery factor can be considered to be a current recovery factor \( f_r^c \), respectively a final recovery factor \( f_r^f \) and having the expressions:

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\begin{align*}
    f_r^c &= \frac{\Delta G_i}{G_0} \quad \text{and} \\
    f_r^f &= \frac{G_i}{G_0}
\end{align*}
\]

\( \Delta G_i \)- gas cumulative production at time ”i”

\( G_0 \)- gas resource

Numerous research papers published and presented at the national and international scientific events in recent years have highlighted the current state of the natural gas fields in the Transylvanian Basin as follows:

- A detailed analysis related to the energetic potential of the most important natural gas fields from Transylvanian basin has highlighted that the actual recovery factors vary between 48-86% in the context of 50-90% final recovery factors. The low difference between the current and the final recovery factors reveals that the analyzed gas fields are in an advanced stage of resources depletion being mature reservoirs.

- Of the over 100 natural gas fields from Transylvanian basin, 20 of them provide about 75% of the total production of the basin. These gas fields are located in the central and south part of the basin with large productive surface and the number of wells in production is sized according to the potential of the reservoir.

- The largest volumes of geological resources are in the fields whose recovery factors vary between 60-80% - although the degree of depletion of these fields is high these gas fields can be candidates for viable programs to capitalize the productive potential.

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3 Marine and Petroleum Geology 23 (2006) 405–442: www.elsevier.com/locate/marpetgeo
Gas accumulations from the most important formations - Sarmatian, Buglovian and Badenian – have similar degrees of depletion, with the exception of the Badenian formation which has the physical parameters of the reservoir unfavorable to efficient exploitation process.

The gas reservoirs from Badenian formation are characterized by high reservoir pressure (250-300 barg), porosity is varying between 3-12% and the permeability is very low specific to tight formation and is varying between 0.001-2 mD. These aspects represent real constrains for the exploitation of Badenian formation from both point of view, technical and economic aspects.

Buglovian and Sarmatian formations are characterized by an advance stage of depletion, the energy level described by the actual reservoir pressure is approximatively 30-35% of the initial reservoir pressure.

Taking into account the current energy level of the most important gas fields from Transylvanian basin, a new approach and perspective is required in order to exploit the reservoir to reach the maximum value of the recovery factor.

**NEW PERSPECTIVES FOR FURTHER EXPLOITATION OF THE GAS FIELDS FROM TRANSYLVANIAN BASIN – AN IMPORTANT SOURCE OF ENERGY FOR ROMANIA**

Given that the most gas fields located the Transylvanian basin are mature and often can not be exploited with attractive recovery factors due to geological,

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4 Tătaru, A., Simescu, B., Şutoiu, F.: Mărirea factorului de recuperare din zăcămintele de vârstă badeniană localizate în Bazinul Transilvaniei, The 10th Regional Energy Forum – FOREN 2010, World Energy Council, ISBN 978-973-720-327-4.
technological or economic constraints, there are still some viable solutions for the continuation of the exploitation to the taken into account such as:

- In geological research, through seismic investigations acquired in the 3D system, new gas accumulations can be revealed, which until now have not been discovered; the geological model of the reservoir can be improved after a computer-based interpretation is performed. 3D seismic data provide detailed information about fault distribution and subsurface structures.

- Complex geophysical investigations may reveal by-passed hydrocarbon formations; Cased hole saturation logs with high resolution and high radius of investigation may highlight thin layers saturated with gas which until now couldn’t be detected through conventional or classical logs.

- Directional drilling can be successfully applied to access undrained zones due to operational difficulties; The Sidetrack operation showed that is a good application to access the gas layers/formations with low recovery factors due to some technical issues during drilling or workover such us junk (downhole tools, bit nozzles, pieces of bits, tubular etc) , mechanical or integrity casing issues, well trajectory etc.

- Use of non-invasive production technologies and fluids to exploit depleted gas formations; Depleted formation are highly sensitive to fluid blockages during workover operations therefore, in order to avoid formation damage and generate additional pressure drops near by formation, non-invasive fluids needs to be used correlated with the rock properties.

  Snubbing technology is a flexible and cost-effective alternative to conventional drilling and workover rigs that showed its benefits during a testing campaign which has been run in 2016 in Transylvanian basin for the following objectives: re-perforation in underbalance condition, restore the well integrity by isolating a casing leak or preventing by running a packer, run completion string, pulling tubing, run frack string and clean out fill;

  This technology proved that is appropriate to be applied in highly depleted fields and additional has reduced the costs with 6% per operation and the productive time per job was 95% (the NPT of 5% was due to lifting operations).

- Using the gas compression process at the local level; lowering the surface pressure of a well by using compression will result in more production. This is true for flowing wells and with nearly all lifted wells. Depending on the individual well, a well production can be increased over a range from only few percent to several times the current production of the well. For flowing gas wells, lowering the surface pressure can significantly increase the production, prolong the life of the well and increase reserves.

- Troubleshoot the wellhead integrity and infrastructure; the facilities are operated since field development phase which means that it may be possible that the current state of production facilities to not ensure a safety process. A detailed
inventory, respectively modifications and improvements to the production system are mandatory for the mature gas field which ultimately can minimize pressure drops.

- Using techniques to stimulate tight gas formations; high pressure stimulation is a method to increase the productivity of the low permeability formations, and finally to increase the recovery factors. A high-pressure stimulation campaign was performed in 1995 on the gas wells from Transylvanian basin, then in 2014 another job was executed in a mature gas field using CO₂ based fluid; all these operations constitute a valuable database that can be the basis for the continuation of the investments in this direction that will lead us to the desired results.

- Continuing the geological researches in the mesozoic, paleogeneic and miocene deposits, in which, until now, no gas accumulation have been discovered; crossing salt is a technical challenge and especially economic (deep depths) but taking into account advanced drilling technologies and fluids that are in continuous improvement, continuing research works through deep drilling in these formations from Transylvanian basin can provide the premises for new potential energy sources in the future.

CONCLUSION

1. Transylvanian Basin is the geological unit that holds the most natural gas reservoirs and has a major impact in ensuring Romania's energy balance.
2. The natural gas fields from Transylvanian basin are mature reservoirs, characterized by an advanced stage of energy depletion.
3. The gas production of the main natural gas fields from the basin is a clear indicator of the energy potential still owned by them; its capitalization can only be achieved through an appropriate exploitation strategy.
4. Increasing the recovery factor from the natural gas fields and especially the efficiency of the exploitation of the reservoirs in the Transylvanian Basin is a matter of strict actuality. Numerous rehabilitation projects are in progress and their results are appreciative and encouraging in terms of the energy potential still held by this huge energy accumulator - the Basin of Transylvania.