ROMANIA
Shale gas could represent energy independence and lower bills

ROMÂNIA
Gazele de șist ar putea reprezenta independența energetică și facturi mai mici

Valentin-Paul TUDORACHE[1], Niculae-Napoleon ANTONESCU[2]

Abstract: *Romania consumes approximately 14 billion cubic meters of gas annually. This quantity is ensured in proportion of 80% of the domestic production, the difference of 20% is imported - at very high prices, through intermediaries - from the Russian Federation. In the near future, shale gas will have a number of favorable geostrategic and geopolitical implications for Romania, in the sense that increasing self-sufficiency and energy security will improve storage capacity and, of course, the abandonment of the main foreign supplier–Russia. Thus, despite a more favorable forecast, shale gas could represent Romania's energy independence and, obviously, lower bills, but there are concerns about the impact on the environment.*

In the paper, after a brief presentation of unconventional hydrocarbon deposits, the geographic and geological analysis of shale gas deposits in Romania is discussed. It also proposes specific programmes and technologies for drilling boreholes to exploit shale gas deposits, including a case study and environmental impact. In conclusion, it shows that Romania can become fully independent in terms of natural gas needs/demand and beyond by exploiting these fields.

Translated with www.DeepL.com/Translator (free version)The authors, under the aegis the General Association of Engineers in Romania (AGIR), the Romanian Academy of Scientists (AOŞR) and the Romanian Academy of Technical Sciences (ASTR), of this paper offer a pass in the magazine of deposits unconventional, highlights potential shale gas resources on the territory Romania, which can describe the important role in the local energy sector and not only.

Keywords: shale gas, energy independence, energy security.

---

[1] Associate Prof. PhD. Eng., Faculty of Petroleum and Gas Engineering, University PETROLEUM - GAS of Ploiesti, Romania, President of A.G.I.R. Prahova branch, Honorary Member of Romanian National Committee of the World Energy Council, e-mail: valentin.tudorache@yahoo.com

[2] Prof. PhD. Eng. PhDHC., HONORARY RECTOR at University PETROLEUM - GAS of Ploiesti, Romania, Honorary Member of the Academy for Technical Sciences of Romania, Honorary Member Academy of Romanian Scientists, Honorary Member of Romanian National Committee of the World Energy Council, e-mail: nnantonescu34@gmail.com

Rezumat: *România consumă anual aproximativ 14 miliarde metri cubi de gaze. Această cantitate este asigurată în proporţie de 80% din producţia internă, diferenţa de 20% este importată -la preţuri foarte mari, prin intermediari- din Federația Rusă. În viitorul apropiat, gazele de şist vor avea o serie de implicaţii geostrategice şi geopolitice favorabile României, aceasta în sensul că sporirea gradului de autoaprovizionare şi a securităţii energetice va îmbunătăţi capacitatea de stocare și, evident, renunțarea la principalul furnizor extern - Rusia. Prin urmare, în ciuda unei previziuni mai încântătoare gazul de șist ar putea reprezenta independența energetică a României și, evident, facturi mai mici, dar există îngrijorări legate de impactul asupra mediului.*
În lucrare, după o scurtă prezentare a zăcămintelor neconvenționale de hidrocarburi, se analizează, din punct de vedere geografic și geologic, zăcămintele de gaze de șist din România. De asemenea, sunt propuse programe și tehnologii specifice pentru forarea sondelor destinate exploatării zăcămintelor de gaze de șist, inclusiv un studiu de caz și impactul asupra mediului ambiant. În concluzie, se arată că România poate deveni total independentă din punct de vedere al necesarului / cererii de gaze naturale și nu numai, exploatând aceste zăcăminte. Lucrarea a fost elaborată sub egida Asociației Generale a Inginerilor din România (AGIR), Academia Oamenilor de Știință din România (AOSR) și Academiei de Științe Tehnice din România (ASTR).

Cuvinte cheie: gaze de șist, independența energetică, securitate energetică.

1. Introduction

Hydrocarbon deposits are abundant in abundance below the Earth's surface.

Conventional deposits are accumulations of fluids (oil, gas and water) in porous-permeable layers, which allow their free flow.

Unconventional deposits do not suffer from hydrodynamic influences, have very low permeabilities (*smaller than 0.1mD*), have low hydrocarbon contents relative to rock volume and are confined to compact rocks scattered over a considerable area. The category of unconventional deposits includes:

- shale oil,
- heavy and very heavy oil reservoirs,
- shale gas,
- tight gas deposits trapped in compact rock formations, such as limestone or sandstone (tight gas reservoirs),
- methane hydrate reservoirs,
- shales and sands bituminous sands,
- coal reservoirs from which methane is mined-CSG / coalbed methane-CBM.

As for shale gas, they are different - although they are still natural gas, shale gas is trapped inside rocks (in clay shales) that need to be ″ fractured ″ (broken / cracked) in order to release the gas. Another difference from normal gases, which are available in a more concentrated way, is that shale gas is usually diffuse (ie, it spreads over a larger area of land). Because of this, numerous wells have to be drilled and analyzed to determine the volatile potential of shale gas. Because they are more difficult to exploit, the methods used differ from those used for conventional gas and also involve both hydraulic fracturing and horizontal drilling. It is, in fact, the hydraulic fractionation combined with horizontal drilling, which perforates the shale layer (up to several hundred meters thick), causing, due to the very high pressures with which the drilling fluid is injected, to break the rocks into particles. fine sand. Therefore, shale gas are captive gas molecules in compact rock formations with low permeability and porosity, being placed at great depths of 2,000 - 3,700 m well below the level of conventional hydrocarbon deposits. [1], [3], [5], [7], [20]

Shale gas is a resource that was imposed relatively late, more precisely 10 years ago [28], with the advances in extraction technology, and its capitalization is based on both economic and strategic considerations, related to ensuring a higher degree of energy security, but coming in stark contradiction with the major ecological objective of drastically reducing greenhouse gas emissions, but also with other requirements for environmental protection.

Consequently, in the local and regional context, shale gas represents a circumstantial chance for increasing energy security, and in a global context - the opportunity to get out of the energy crisis. As a result, by exploiting unconventional deposits, Romania can become an energy-independent country, thus giving up gas imports (20%) and, at the same time, avoiding the risks caused by the war between the Russian Federation and Ukraine.

2. Clay formations with gaseous potential - shale gas in Romania

According to the Energy Information Administration (EIA) report on shale gas reserves in the European Union (EU), after Poland (4,190 billion cubic meters) and France (3,879 billion cubic meters), Romania ranks third with 1,444 billion cubic meters -so it can reduce the dependence on imported gases. Although the value potential of shale gas has long been recognized, a number of challenges have dampened expectations.

In Romania, shale gas formations with shale gas potential are located in orogen units, in corrugated structures and in platform units (from the Carpathian foreland), at depths exceeding 2,000 - 3,700 m, thus (see Fig. 1):

- Moesica Platform - Romanian Plain with its extension in South Dobrogea,
- Scythian Platform (Bârlad Depression),
- South of the Moldovan Platform. [12], [20]

Regarding the thickness of the formations, it is variable (100 ÷ 2,000m), and its values are influenced by the tectonic framework, the paleo-relief of the basin during their accumulation and by the frequency of drillings that intercepted these formations.

Regarding the Pannonian Depression and the Black Sea Continental Shelf, the available information does not allow such an assessment.

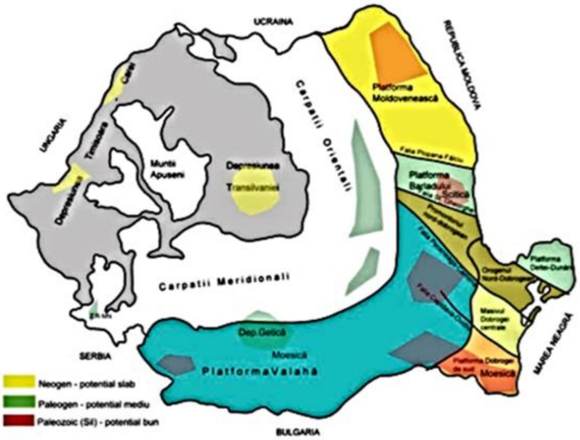

Figure 1. Map of ROMANIA with the indication of the areas with shale gas potential [2], [20], [29]

The results of the analyzes indicate a high potential for the Silurian formations from the Moesic Platform, the Scythian Platform, and the Moldavian Platform (see Fig. 2).

Potential living conditions are also met in the Getic Depression, the Pannonian Depression, and the Transylvanian Basin.

In the Eastern Carpathians and the Getic Depression, Oligocene formations have medium potential.

For the Permian and Jurassic formations in the Southern Carpathians (Resita Area - New Moldova), for the Carboniferous and Jurassic formations in the Moesic Plateau and for the Cretaceous and Miocene formations in the Transylvanian Basin, the potential is weak.

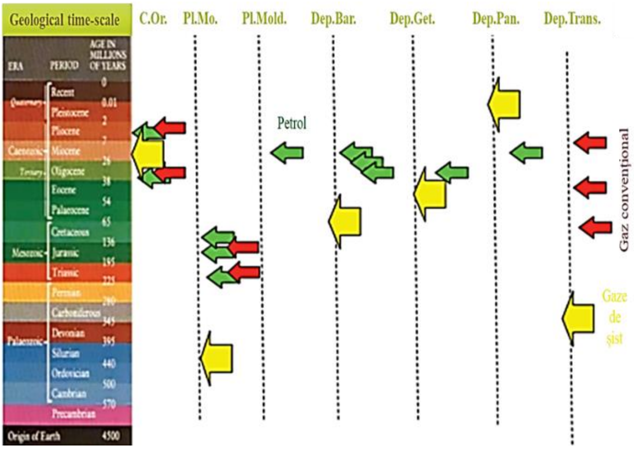

Figure 2. Geological formations with shale gas potential in Romania [2], [12], [20], [29]

The yellow arrow indicates the shale gas in the mentioned formations.

The evaluation of shale gas reserves can be done only after the design of exploration boreholes to establish, through a 3D approach - the geometry (architecture) of rock bodies, their thickness, lateral extension, lithological homogeneity, permeability of the formation, as a whole.

Formations with a good potential are considered to be those in which the values of Total Organic Carbon (TOC-wt%) are higher than 2 ÷ 4% (as the maturity of the organic substance increases the content of Total Organic Carbon may have values between $0 \leq TOC \leq 12$). [2], [20]

For the exploitation phase, formations with thicknesses greater than 50 m must be taken into account, in the conditions of a lithological homogeneity.

In conclusion, Romania presents favorable prospects for highlighting unconventional gas resources, associated with clay formations known for their potential to generate hydrocarbons (shale gas), coal seams (CBM) and / or sandstones with low failure without the application of stimulation methods, by hydraulic fracturing (tight gas).

3. Proposed construction programs and technologies specific to well drilling destined for unconventional gas fields

3.1. Choice of drill string and bottom assembly (BHA)

The standard gasket for drilling vertical or moderately inclined wells, below 50º - 60º, is shown in Figure 3. [6], [7], [20], [23]

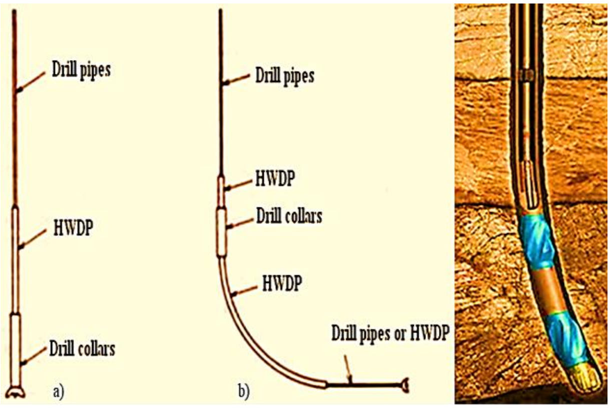

Figure 3. The composition drilling rigs [4], [6], [7], [20], [23]
(a - *vertical drilling well*; b - *horizontal drilling well*)

In the case of vertical drilling, it is known that the need to press on the screed is achieved with approximately 75% of the weight of the heavy rods (see Fig. 3.a).

In the case of horizontal probes, pressing on the screed is done by placing the heavy rods, possibly part of the intermediate ones, in an area with low or even vertical inclination (see Fig. 3.b).

Figure 4 shows a simplified set of forces involved in conducting a directed drilling and the system of forces in BHA (Bottom Hole Assembly). [6], [7], [20], [23]

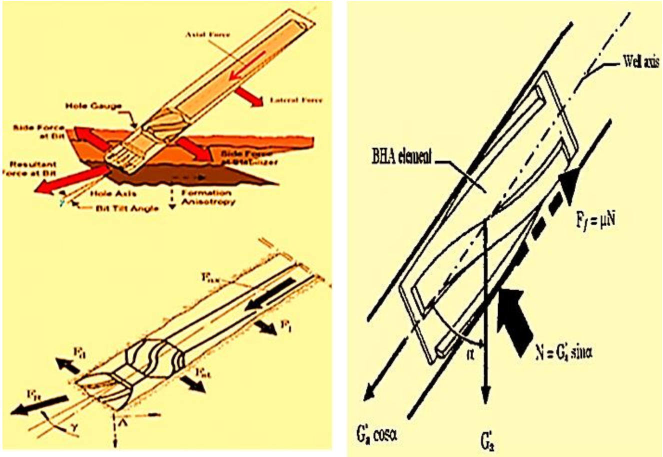

Figure 4. The ensemble of forces in a directed drilling
and the system of forces in BHA

In Figure 4:

F_{ax} represents the axial force, component of BHA;
F_l – lateral force, component of BHA weight;
F_{st} – lateral force at the stabilizer;
F_d – deflection force at the drilling rig;
A – rock anisotropy
γ – the angle between the axis of the probe and the screed;
FR – the resulting force of the screed.

Bottom Hole Assembly weight and weight on the bit (WOB) [6], [7], [23]:

a) If BHA is not rotating, we have the relationship:

$$F_f = \mu \cdot G_a \left(1 - \frac{\rho_f}{\rho_o}\right) \sin\,\alpha \tag{3.1}$$

where:

F_f is the friction force.
N – normal reaction between BHA element and well wall:

$$\mathrm{N} = G_a^{'} \cdot \sin\alpha \tag{3.2}$$

μ –coefficient of friction.

In the same time, BHA weight in drilling fluid is:

$$G_a^{'} = G_a \left(1 - \frac{\rho_f}{\rho_o}\right) \tag{3.3}$$

The net weight contribution of BHA element is:

$$G_s = G_a^{'} \cdot \cos\alpha - F_f = G_a \left(1 - \frac{\rho_l}{\rho_o}\right)(\cos\alpha - \mu \sin\,\alpha) \tag{3.4}$$

The practice results obtained with MWD systems allows to simplify the relationship:

$$c_s \cdot G_s = G_a \left(1 - \frac{\rho_f}{\rho_o}\right) \cos\alpha \tag{3.5}$$

$$c_s = 1 + \frac{c_{sm}}{100} \tag{3.6}$$

(*c_{sm} = 10 ÷ 15% and represents the coefficient marginal safety*) so

$$G_a = \frac{G_s \cdot c_s}{\left(1 - \frac{\rho_f}{\rho_o}\right)\cos\alpha} \tag{3.7}$$

b) When using the drill strings in compression (CS):

$$c_s \cdot G_s = G_a\left(1 - \frac{\rho_f}{\rho_o}\right)\cos\alpha + 0{,}9 \cdot F_{cr} \tag{3.8}$$

$$G_a = \frac{G_s \cdot c_s - 0{,}9F_{cr}}{\left(1 - \frac{\rho_f}{\rho_o}\right)\cos\alpha} \tag{3.9}$$

where:

F_{cr} *is the critical buckling force* (loss of stability) of the drill string (Dawson and Pasly`s relation):

$$F_{cr} = 2\sqrt{\frac{2EIq_p \sin\alpha}{D_s - D}} \tag{3.10}$$

3.2. Proposed construction programs for drilling wells for unconventional gas fields

In general, the construction program consists of 3-4 columns, which must close the first intervals, and the horizontal portion will be equipped according to the conditions encountered in the productive layer.

Figure 5 shows two construction programs of wells with extended range (ERW), made in Romania.

Figure 6 shows the Program for the construction of a shale gas well, in which the realization of a horizontal well involves, first of all, a vertical drilling to a known depth, followed by KOP (kick-of point - change point of the drilling direction), then of the build-up area - deviated portion - until it reaches the productive layer and, finally, of the horizontal drilling on the projected length which can reach 2,500 m up to 3,700 m. part of the well, of horizontal section, allows a contact with the shale formation much more important than the one related to the vertical drilling.

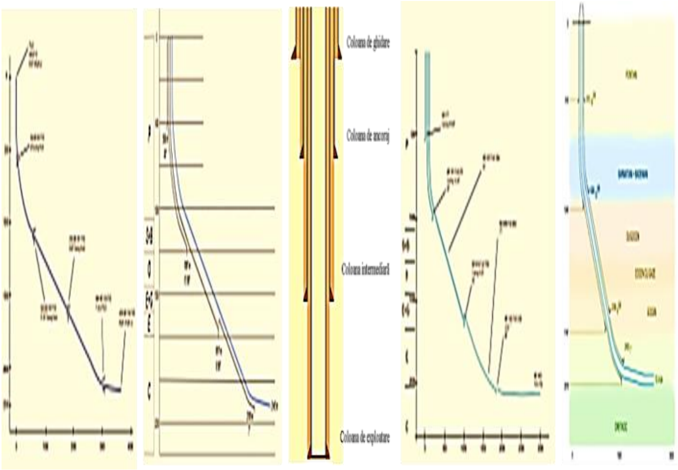

Figure 5. Construction programs for ERW wells,
realized in Romania [2], [5], [6], [7], [20], [23]

Obviously, from the KOP, the trajectory starts with vertical deviation rates of 4° / 30 m - 10° / 30 m ÷ 20° / 30 m (in practice, this means that the starting point of the change of direction of the KOP is approximately 100 - 200 m above the horizontal section). [6], [7], [9], [20], [23]

For the exploitation of shale gas, at present, horizontal drilling, combined with the hydraulic fracturing / cracking operation, is most often used efficiently. This is especially the case with ERD (Extended Reach Drilling) drilling, with horizontal section lengths of thousands of meters (*for example, for several deposits in Canada and America, the typical scheme of the construction program could be the from Figure 6.c In the USA, a country with rich experience in this field, the lengths of the horizontal sections of the wells usually vary between 1000 m and 2000 m, but there were also cases in which these lengths reached even 6000 m*). *[20]*

Note [20]:

1) Horizontal wells have been dug in our country since 1995 (for example: Clejani well 1).

2) Directed and horizontal wells were made mainly by SC Foraj Sonde Tg. Mureş (in Fig.3 the construction program of such wells made in Romania was presented).

Therefore, special measures must be taken to ensure that the construction and equipment of the wells are completed in curved, inclined, and horizontal intervals. Obviously, these measures are mainly intended to:

prevent the loss of the stability of the well wall in the intervals to be consolidated, as a result of the long time necessary to carry out the piping operations; prevention of problems caused by the introduction of columns in the curved parts, due to their rigidity and length; preventing the columns from catching at very inclined and horizontal intervals caused by very high normal and frictional forces; ensuring the achievement of successful cementing by centering the columns, using buffer fluids, respectively of adequate volumes and flows of cement paste; the use of paste recipes to ensure the realization of cement stones resistant to the operations of putting into production and subsequent operation of the wells. [20].

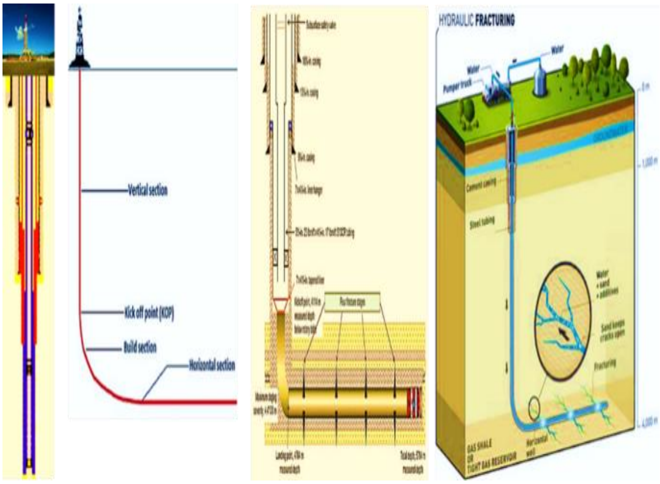

Figure 6. The construction schedule of a shale gas well [20], [23], [31]
(a - *general scheme of the construction program*; b - *diagram of the construction program*; c - *typical scheme of the construction program*; d - *hydraulic fracturing / cracking* - the big picture)

3.3. Technology of orientation modern wells specific to well drilling

Today - *in the DIGITAL ERA* - some modern guidance technologies are established that can answer these problems, such as [6], [20]:

– Automation Technology for Directional Drilling,
– Rotary Steerable System,
– Reel Well Drilling,
– Geosteering Drilling,

and which obviously use bottom motors and drilling measuring devices (MWD).

In terms of computing technology, it plays a key role in drilling. For example, in Figure 7 shows the Pegasus Vertex, Inc. drilling software. (PVI), this is the result of the latest computing technology combined with complete drilling engineering skills. *(!!! In fact, it is the result of over a decade of research and development*) [20].

PVI software is equipped with state-of-the-art animation and 3D visualization technology to present computational results (geometry and graphics)

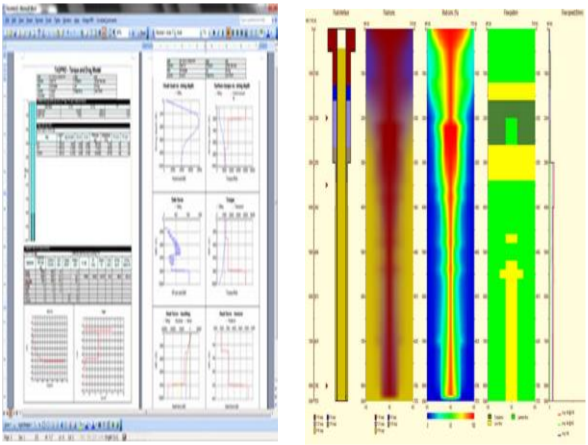

Figure 7. Pegasus Vertex Software, Inc. (PVI): computational results and overview-3D [20]

Well route monitoring is based on the one hand, on the use of high-performance electronic detection modules in MWD and LWD systems, and on the other hand, on a high surface processing capacity of data collected from the probe (facies, temperatures, pressures, nature of fluids, etc.) in order to establish the position of the screed, maintaining or modifying the route etc. The fluids used to make these probes must meet specific requirements. Emphasis is placed on very light fluids such as gases, foams, inhibitory fluids (clear solutions), very low filtrate fluids, brittle gel fluids, synthetic petroleum-based fluids etc. [16], [25]

3.4. Case Study [23]

The most favorable conditions for shale gas exploitation are the Oligocene deposits in the Miocene-Pliocene area and the Paleogene flysch in Romania (see Fig. 1).

These deposits are composed of pelagic and semi-pelagic clays, mostly bituminous shales, alternating with fine or sandy sandstone. In some areas, due to the increasing content of calcium carbonate, the clays are replaced by marls.

Calculating the characteristic points of the horizontal wells profiles, assuming the following initial data:

– the vertical depth of the well, $H = 2500$ m;

– casing shoe of anchorage column depth, $h_1 = 400$ m;

– the depth where is localized the initiation of diversion point (from the casing shoe of the anchorage column,) $h_2 = 1100$ m;

– horizontal section length, $a_3 = 910$ m;

– intensity of vertical deflection, $i_v = 1°/ 10$ m;

– the acceptance angle slope, $\alpha = 90^o$

– the radius of curvature, $R = 561$ m

Based on the initial data and following the calculations performed, the estimated values are presented in table 1, and the profile of the proposed probe is presented schematically in Figure 8.

Table 1. **Points characteristic values estimation** [7], [23]

Deviation initiation, *A*	**Drilled length, *L* [m]**	**Slope, *A* [º]**	**Heigth, *H* [m]**	**Horizontal movement, *a* [m]**
-	$h_1 + h_2 = 1500$ m	-	$h_1 + h_2 = 1500$m	-
End of deflection, *B*	$l_B = h_1 + h_2 + (\pi \alpha R/180)$ ≈ 1390 m	$\alpha = 90^o$	$h_B = H = 2500$m	$a_2 = R = 561$m
Targhet, *T*	$l_T = h1 + h2 + (\pi \alpha R/180) + a_3$ ≈ 2000 m	$\alpha = 90^o$	$H = 2500$m	$A = R + a_3$ = 1471 m

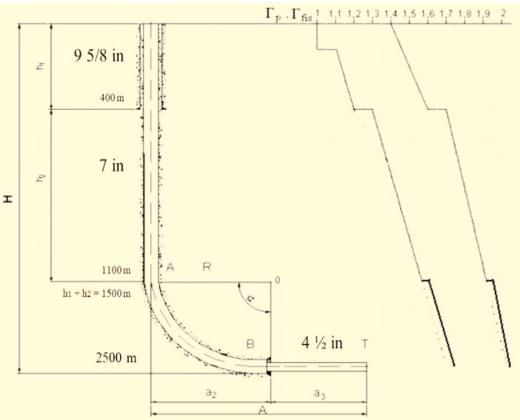

Figure 8. Profile of the proposed well [6], [23]

4. Problematic air, water and the environment ambient

[2], [13], [20], [23], [25], [31]

4.1. The problemic of air

The measures required to reduce the impact on the air environment factor, for each stage of work separately, refer mainly to the application of best practices in both drilling and hydraulic cracking so as to cross sensitive areas underground. to avoid methane gas pollution.

By reducing the volume of work and establishing an execution schedule and correlating the work schedules of the equipment in the work site with those of the production bases, no exceedances of the maximum allowed values are expected. Therefore, the potential impact generated is considered to be low.

4.2. The problemic of the water

A major problem is questioning the water.

Specialists have shown that each shale gas well requires between 10,000 and 30,000 m.c. of water, approx. 500 t of sand and approx. 50 t of chemicals. In total, between 60% and 80% of the mixture is returned to the surface. The rest, with 0.5% chemicals, remains in the fractured rock.

In all cases, this water is permanently lost, which is a problem in arid areas.

As for surface water, it must be stored and lightly treated for reuse during "well injection" operations or, at best, for reuse for other fractures.

Nothing would prevent from a technical point of view a cleaner solution, which would allow for example reuse in agriculture, but the cost being higher than approx. 4 (four) times, obviously, such a solution must be imposed.

4.3. The problemic of the environmental ambient

The exploitation of shale gas has many implications for the environment, which some argue justifies the ban, while proponents of this technique believe that stricter regulations and practices will allow the correction of certain drifts found.

"Fracking", or hydraulic fracturing, is one of the main topics of contention. This consists of injecting a mixture of water + sand + chemical additives through the drill pipes and under very high pressure. This mixture will crack the so-called "bedrock" in which the target gas is located, most often at a depth of 2,000 to 3,700 m. The mixture is then partially pumped back to the surface, the cracks created releasing the shale gas.

The cracks created are generally only a few tens of meters, 200-300 m in extreme cases, which excludes the possibility of a gas rising to the groundwater, often 1000 m above.

The risk of noticing these substances rising directly to the surface is considered extremely low.

Obviously, in reality, the main risk occurs in the upper part of the wells, where the groundwater is crossed, mainly due to a poor tightness of the cement layer that surrounds the metal drilling pipes.

The risk also exists in any type of drilling, but fracturing adds an additional risk because there is a very strong pressure in the tubes to successfully fracture the rocks in depth, so these pressures are very strong near the surface, and here there may be evident cracks or accidents. [11], [24]

Another major feature of shale gas is the amount of drilling in a small area. The risk - even if it is small - of a leak is therefore multiplied by the number of installations.

5. Conclusions

Romania could become independent of imported gas, which currently covers approx. 20% of domestic gas consumption.

Beyond the revitalization of entire industries as a result of shale gas, Romania can become an energy independent state. In this way, it can prepare for the status of natural gas exporter, and some of its coal-fired power plants can be converted to burn gas. At the same time, the coal that is no longer used in Romania can be exported to the EU and other states, which would lead to a decrease in price.

Invigorating an operating business that would involve equipment, specialists, logistics and transportation.

Education in this energy sector would benefit, given the need for people specialized in the oil and gas industry, in petrochemistry (! And not only).

The final price at which the gas is sold to the final consumer is composed of the price of gas from domestic production and import production, according to a certain proportion, the transport tariff, the distribution tariff, the storage tariff and various other taxes.

Regarding the world map of energy security, shale gas could represent Romania's energy independence, obviously with lower bills, but with an environmental impact that calls into question economic profit.

As a general conclusion, the authors consider that the value potential of gases from unconventional deposits on the Romanian territory is significant. Therefore, the authors recommend that the exploration and exploitation of shale gas is an opportunity and a necessity of the moment both in terms of the application of modern technologies and the adoption of an appropriate regulatory framework to reduce the risks caused by the war between Ukraine and the Russian Federation.

REFERENCES

[1] Antonescu, N.N.: *The Romanian Petroleum-Gas Higher Education-Past, Present and Future*, Editura Universităţii Petrol-Gaze din Ploieşti, 2000.

[2] Antonescu, N.N. (coordonator) ș.a.: Centrul European de Excelenţă în domeniul gazelor naturale din argile gazeifere, *Raportul: Resurse de gaze naturale din zăcăminte neconvenţionale–potenţial şi valorificare*. CNR-CME, Bucureşti, 15 noiembrie 2013.

[3] Antonescu, N.N., and others, *The Petroleum and Gas History of Romania*, Editura AGIR Publishing House, Bucureşti, 2017.

[4] Antonescu, N.N., and others, *Fabricarea, exploatarea, mentenanţa şi asigurarea calităţii echipamentelor petroliere,* Editura Universităţii din Ploieşti, 2004.

[5] Antonescu, N.N., Avram, L.: *Foraje dirijate şi orizontale pentru exploatarea gazelor din zăcăminte neconvenţionale*, EMERG 1, 2015.

[6] Avram, L., Tudorache, V. P.: *Elements of Horizontal and Directional Drilling Optimization, 7th Annual Conference and Exhibition* - SEE UPSTREAM 2015-ONSHORE & OFFSHORE TECHNOLOGY IN THE BLACK SEA REGION, Bucharest, Romania, April 2015.

[7] Avram, L., Tudorache, V.P.: *Forajul Sondelor 3* - Suport de Curs, UPG-Ploiești, 2015.

[8] Avram, L.: *Elemente de tehnologia forării sondelor,* Editura Universităţii Petrol-Gaze din Ploieşti, 2011.

[9] Avram, L.: *Foraj dirijat*, Editura Universal Cartfil, Ploieşti, 1999.

[10] Avram, L., *Elements of drilling management*, Editura Universităţii din Ploieşti, 2011.

[11] Avram, L., Tudorache, V.P.: *Dificultăți și accidente tehnice în foraj* - *S*uport de Curs, UPG-Ploiești, 2015;

[12] Beca C., Prodan D.: *Geologia zăcămintelor de hidrocarburi*, Editura Didactică şi Pedagogică, Bucureşti, 1983.

[13] Tudorache, V. P.:*Controversele pe tema gazelor de șist. Numai abordările științifice pot determina soluții optime*, AGIR, Univers Ingineresc nr.: 3/2014, 1-15 februarie 2014

[14] Tudorache, V.P., Avram, L., Antonescu, N.N.: *Aspects on offshore drilling process in deep and very deep waters;* Technical Sciences Academy of Romania (ASTR) - Subdivision: F. Petroleum and Mining Engineering, Journal of Engineering Sciences and Innovation (JESI) https://jesi.astr.ro/wp-content/uploads/2020/07/7_Tudorache-V.P.pdf, Volume 5, Issue 2 / 2020, pp. 157-172, ISSN-L 2537-320X and ISSN 2601-6699, AGIR Publishing House – June 2020.

[15] Tudorache, V.P., Antonescu, N.N.: *Challenges of oil and gas exploration in the Arctic;* Technical Sciences Academy of Romania (ASTR) - Subdivision: F. Petroleum and Mining Engineering, Journal of Engineering Sciences and Innovation (JESI) https://jesi.astr.ro/wp-content/uploads/2020/10/8_Tudorache-Valentin-Paul.pdf, Volume 5, Issue 3 / 2020, pp. 273-286, ISSN-L 2537-320X and ISSN 2601-6699,

[16] Tudorache, V.P., Avram, L., Antonescu, N.N.: *ROMANIA AND GEOTHERMAL ENERGY: An unconventional, clean and renewable energy source,* CONFERINȚA ȘTIINȚIFICĂ NAȚIONALĂ și INTERNAȚIONALĂ-AOȘR, 10 iunie, ROMÂNIA, 2021

[17] Tudorache, V.P., Avram, L., Antonescu, N.N.: *PROCESS ANALYSIS AND RISKS OF THE EXPLOITATION OF NEW HYDROCARBON DEPOSITS DISCOVERY OFFSHORE, IN THE DEEP WATERS OF THE BLACK SEA*, CONFERINȚA ȘTIINȚIFICĂ NAȚIONALĂ-AOȘR, 18 noiembrie, București, ROMÂNIA, 2021.

[18] Tudorache, V.P., Avram, L., Antonescu, N.N.: *CONSIDERATIONS ABOUT INCREASING UNDERGROUND STORAGE CAPACITY OF NATURAL GAS IN EXHAUSTED OIL AND GAS FIELDS,* Lucrările celei de-a XIV-a ediții a Conferinței anuale a ASTR - CHIȘINĂU, 17-18 octombrie, Moldova, 2019.

[19] Tudorache, V.P.: *Aspecte privind cauzele instabilității pereților găurilor de sondă,* MPG/ Nr.5, 2018.

[20] Tudorache, V.P., Antonescu, N.N.: *Shale gas could represent energy independence and lower bills, A*OȘR, CONFERINȚA ȘTIINȚIFICĂ NAȚIONALĂ: Secțiunea Științe inginerești, 6 mai, București, ROMÂNIA, 2022.

[21] Tudorache, V. P.: *Aspecte referitoare la zăcămintele cu caracteristici favorabile forării sondelor direcționale;* Monitorul de Petrol și Gaze S.I.P.G., ISSN 1583-0322, Nr. 12 / 2018.

[22] Tudorache, V.P.: *Aspecte generale privind optimizarea forajului dirijat prin sistem de sonde multilaterale și creșterea productivității sondelor cu investiții minime,* S.I.P.G. Bucureşti, MPG - ISSN 1583-0322, Nr. 4, 2017.

[23] Tudorache, V. P.: *Forajul sondelor – proiect 2*, IFR, Anul IV, 2015

[24] Tudorache, V.P., ș.a., *Soluții și riscuri pentru creșterea capacității de înmagazinare subterană a gazelor în zăcăminte depletate,* WEC CENTRAL & EASTERN EUROPE ENERGY FORUM FOREN 2018 14th Edition, 10 - 14 June 2018 Vox Maris Grand Resort Costinești, Constanța, ROMÂNIA, 2018;

[25] Tudorache, V.P.: *Aspecte privind fluidele utilizate la forajul sondelor în zone cu ape adânci,* MPG, 2018;

[26] Avram, L., Troquet, M., Dussap, C.G., Lixandru, G., *Dicţionar de Petrol şi Gaze Englez-Român-Francez,* Edit. Karta-Grafic, Ploieşti, 2008.

[27] Avram, L., Burlan, A.M, *LEXIC Englez-Român-Francez al principalilor termini de Foraj-Extracţie-Proiectare,* Edit. Imprimex, Vol. I 1994 şi Vol. II 1995.

[28] *** *Unconventional Gas: Potential Energy Market Impacts in the European Union,* JRC Scientific and Policy Reports, 2012.

[29] *http://www.petroleumclub.ro/downloads/links/Raport_CENTGAS_nov_2013.pdf*

[30] *API - American Petroleum Institute.*

[31] *www.google.com*

[31] ****FOREN-2022, Costinești, Constanța, România, 2022.*

Acronyms list [20], [23], [30], [31]

API – American Petroleum Institute
APWD – Annular Pressure While Drilling
BHA – Bottom Hole Assembly
BOP – Blowout Preventer
CIRC – Circulation
CLDS - Closed Loop Drilling System
DB – Drill Bit
DC – Drill Collar
DD – Directional Drilling
DIF – Drill in Fluids
DP – Drill Pipe
DRL – Drilling
DS – Deviation Survey, (Directional System)
DVT – Differential Valve Tool (for cementing multiple stages)
ECD – Equivalent Circulating Density
E&P – Exploration and Production
HDD - Horizontal Directional Drilling;
HP – Hydrostatic Pressure
HPHT – High-Pressure High Temperature (same as HTHP)
HWDP – Heavy-Weight Drill Pipe
IADC – International Association of Drilling Contractors
ID – Inner or Internal Diameter
JU – Jack-Up drilling rig
KOP – Kick-Off Point Directional Drilling
LCM – Lost Circulation Material
LGS – Low (specific-)Gravity Solids
LWD – Logging While Drilling
MD – Measurements / Drilling Log
MPD - Managed Pressure Drilling;
MW – Mud Weight
MWD – Measurement While Drilling
NMDC – Non-Magnetic Drill Collar
OD – Outer Diameter
O&G – Oil and Gas
OWC – Oil Water Contact
PCDC – Pressure Cased Directional (Geometry i.e. borehole survey) MWD tool
PCE – Pressure Control Equipment
PDC – Perforation Depth Control
PDM –Positive Displacement Motor
POOH – Pull Out Of Hole
POR – Density Porosity Log
PV - Plastic Viscosity
RKB – Rotary Kelly Bushing (a datum for measuring depth in an oil well)
ROP – Rate of Penetration
RPM – Rotations Per Minute
RSS – Rotary Steerable Systems
RT – Rotary
RTE – Rotary Table Elevation
SBF – Synthetic Base Fluid
SBM – Synthetic Base Mud
TA – Top Assembly
TBG – Tubing
TD – Target Depth
TDS – Top Drive System
THD – Tubing Head
TOC – Top Of Cement
TOL – Top Of Liner
TVD – True Vertical Depth
TVDRT – True Vertical Depth (referenced to) Rotary Table zero datum
UBD – Under Balance Drilling
WIMS - Well Integrity Management System
WOB – Weight On Bit
WPS - Water Phase Salinity
WT – Well Test
YP - Yield Point (YP)
ZOI – Zone of Influence