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SOME CONSIDERATIONS REGARDING THE UNCONVENTIONAL GAS RESERVOIRS IN ROMGAZ

1. INTRODUCTION

The need for discovering the alternative energy resources, beside the classical and conventional ones, became nowadays a continuous challenge and it seems to become a viable solution in order to overcome the worldwide energetic crisis . If the concept of unconventional gas is today more frequently used in world oil and gas industry, in Romgaz it hasn't been implemented and developed until now, even if unconventional reservoirs have been already tested in the past, without knowing and using this terminology.

2. UNCONVENTIONAL GAS CONCEPT DEFINITION

In the broadest sense, the unconventional gas can be defined as natural gas which is usually more difficult to extract or to be produced at economic flow rates, by applying the available classical technologies, unless the wells are not stimulated by different procedures as hydraulic fracture treatments, acidizing, reperforating or perforating with deeper penetration guns, drilling horizontal or even multilateral wellbores,the stimulation methods depending for each well on the reservoir parameters and the economic status.

The practical experience has been demonstrated that unconventional gas reservoirs are not typical, being associated to different conditions, so can be deep or shallow, high or low pressure, high or low temperature, blanket or lenticular, homogeneous or naturally fractured, compact or interbedded with one or more layers.

The unconventional gas reservoir is related to a low permeability formation, that is producing mainly dry gas. The most part of the low permeability reservoirs are developed in

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sandstones but also in carbonates, shales and coalbed methan were produced high amounts of gas.

However, today we can say that our attempts are also very timid, but we are often encouraged by the successful results obtained during the wells testing. Based on Romgaz experience, we could classify our unconventional gas reservoirs in two main categories: shale gas and tight gas formations.

2.1. Shale gas

As is the name, the shale gas represents the natural gas produced from shale, which geologically speaking, is a very fine –grained sedimentary rock, that is easy breakable into thin, parallel layers. It's a very soft rock, but it doesn't disintegrate when it becomes wet.

Shales that host economic amounts of gas have a number of common properties: are rich in organic material (0,5%–25%) and are usually mature petroleum source rock in the thermogenic gas window, where high heat and pressure have converted petroleum into natural gas. They are rigid enough to keep open fractures.

Because gamma radiation is often correlated with high organic carbon content. shale intervals with high natural gamma radiation are the most productive.

The greatest amount of gas is extracted from natural fractures, where the gas is produced immediately, but also some gas is held in pores, or is adsorbed onto the organic material. Because shales are usually characterized by a low permeability, the natural gas extraction from these reservoirs is more difficult and perhaps more expensive due to the modern technology and advanced hydraulic fracturing methods which must be involved.

However, in the last period, the shale gas production has known a very fast development and play a key role in supplying the energy demands in many areas from the world, especially in United States and also in Canada, Europe, Asia and Australia

2.2. Tight gas formations

Tight gas formations are defined in general as sandstone formations, very compact, with a very low permeability (relatively impermeable), noting that the degree of permeability depends upon the size, shape of the pores, interconnectivity, and the extent of this. Actually, the definition of a tight gas reservoir is a function of many physical factors as permeability, net pay thickness, reservoir and flowing pressure, drainage area,wellbore radius, skin factor.

Extracting gas from a tight formation involves also more efforts, including several and in the same time very expensive techniques as fracturing and acidizing.

As shale gas areas, the tight gas reservoirs are developed in the same zones, especially in North America.

3. CASE STUDIES OF UNCONVENTIONAL GAS FORMATIONS IN ROMGAZ

After a short description of the general concept and what an unconventional gas reservoir means, our paper will present some case studies from different areas, belonging to Romgaz, which provide the existence of natural gas in these types of reservoirs.

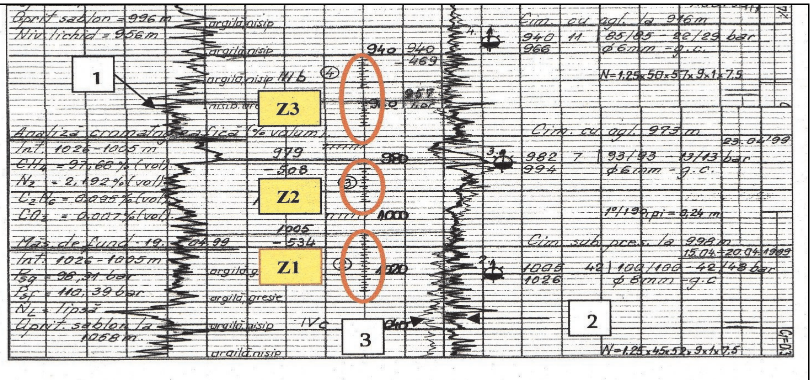
We mention that the old Romgaz concept regarding well testing was related to perforating only the porous permeable formations, but some experiments developed in the last years proved to have good results in unconventional formations.

We start to present three zones tested successively with unexpected results, in a shaly section of Buglovian age (lower Volhynian) in one well (**A_1**) belonging to the gas field **„A”**, located in the southern part of Transylvanian Basin. Description of cutting samples highlights that a shaly zone was passed by the well.

The results are summarized in the Table 1 and graphically represented in the Figure 1 below.

Table 1

Zone	Interval m	Static pressure T/C bar	Dynamic pressures T/C bar	Flowrate Stcm/day
1	1026–1005	100/100	ϕ 8 mm– pd = 42/48	42.000
2	994–982	93/93	ϕ 6 mm– pd = 13/13	7.400
3	966–940	85/85	ϕ 6 mm– pd = 22/29	11.700



Notes semnification
1 - SP– spontaneous potential
2 - potential resistivity curve
3 - gradient resistivity curve
Z1, Z 2, Z 3 – shaly zones (perforatioms)

Fig. 1. Well A_1 – Fragment of the standard electrical log

Another shaly section of Buglovian age, confirmed by the core description, has been also tested with good results in a gas field **„B”** (southern – western part of Transylvanian Basin), where in the well $\mathbf{B_1}$, from the perforated interval: 1028–994 m (Sa X – selectively) was obtained a gas flow rate of about 100.000 stcm/day (Fig. 2).

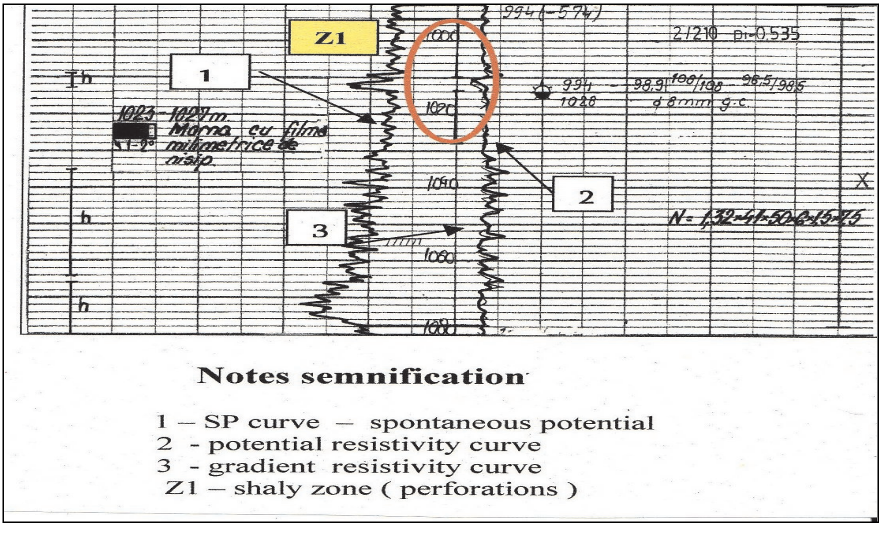


Fig. 2. Well B_1 – Fragment of the standard electrical log

Table 2

Zone	Porosity %	Permeability mD	Well	Tested interval m	Flowrate Stcm/day
Bn XIV	**3–8***	**0.1–0.5****	$\mathbf{C_1}$	**2730–2646**	**14.600 (test)**
Bn XV	**3–8***	**0.1–0.5****	$\mathbf{C_2}$	**2795–2805**	**7.000 (the well is in production)**
	3–8*	**0.1–0.5****	$\mathbf{C_3}$	**2866–2816**	**3.300 (the well is in production)**
Bn XVI	**3–9***	**0.1–0.8****	$\mathbf{C_3}$	**3056–3000 *****	**10.000 (the well was produced from this zone)**
Bn XVII	**3.5–6*******	**0–0.3*******	$\mathbf{C_3}$	**3217–3157 (open hole test)**	**5.800 (test)**

* – Porosity derived from Density – Neutron crossplot from petrophysical analyses
** – Permeability derived from core analyses
*** – Core description: 3036 – 3040 = 4 m – blocky sandstone – (Bn XVI) – well **C3**
**** – Parameters obtained from the core analysis: interval: 3154 – 3158 = 4 m (Bn XVII) – well **C3**

Tight gas sandstones have been tested in the past in many gas fields belonging to Transylvanian Basin, in low permeability Badenian formations.

So, in gas field, **„C"**, which is the greatest gas field, located also in Transylvanian Basin (central part), lower Badenian units (XIV to XVII) should be considered good candidates for tight gas exploitation. The reservoir appears as a blocky interbedded sandstone. The physical parameters derived from the core analyses reveal a tight zone, with low porosity and permeability as presented in the table below (Tab. 2).

We mention also that initial flow rate in the well $\mathbf{C_2}$, was about 3000 stcm/day and after an **acid job**, the flowrate has been increased to 7000 stcm/day.

Another interesting issue is that in he well $\mathbf{C_1}$ a kick off was happened and the mud weight was increased from 1.40 kg/cdm to 2 kg/cdm and also in well $\mathbf{C_2}$ a lot of kick offs were happened from Bn XV to the bottom.

The perforated intervals and the obtained results are presented in the Figures 3, 4, 5 and 6.

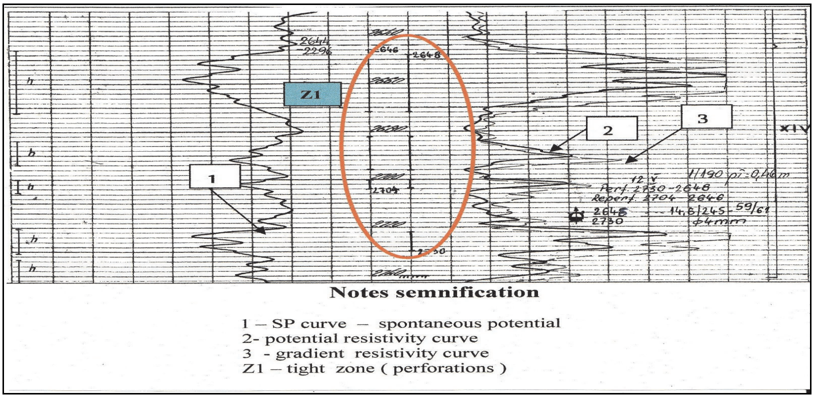


Fig. 3. Well C_1 – Fragment of the standard electrical log

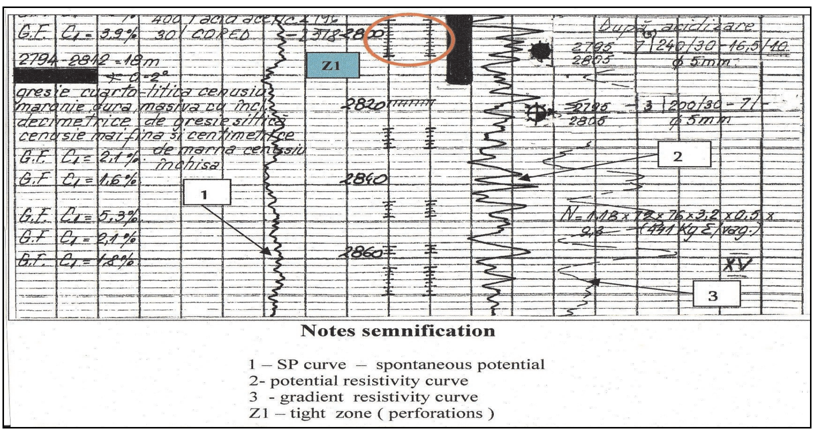


Fig. 4. Well C_2 – Fragment of the standard electrical log

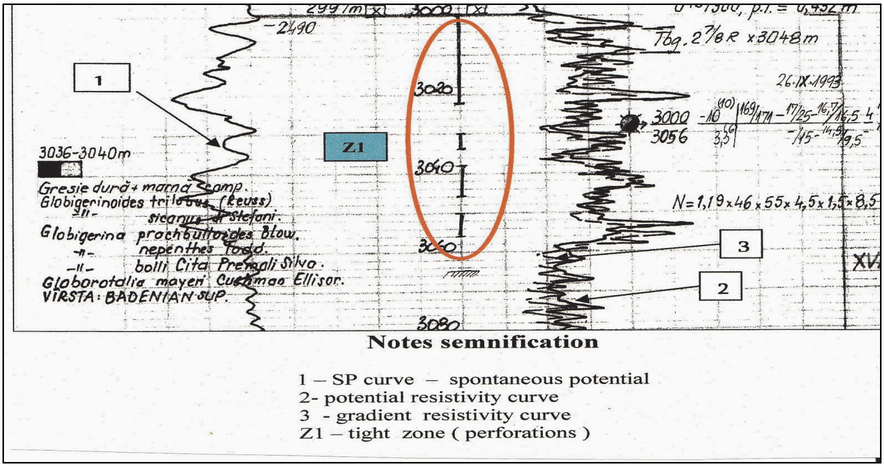


Fig. 5. Well C_3 – Fragment of the standard electrical log

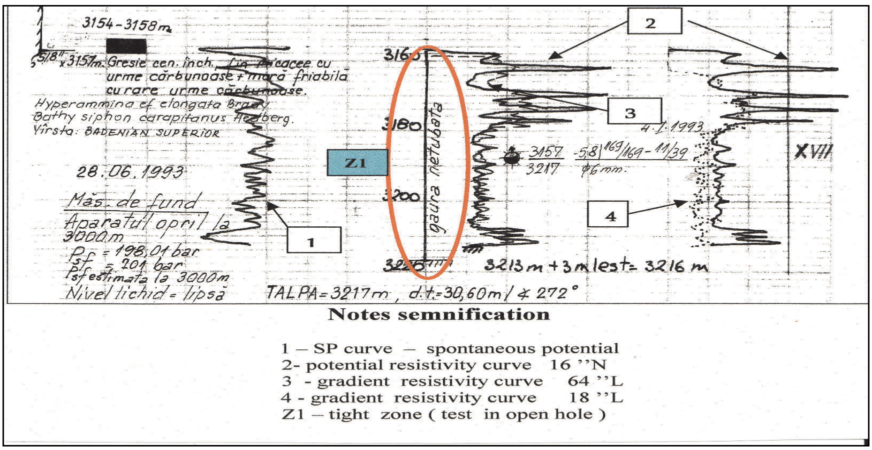


Fig. 6. Well C_3 – Fragment of the special electrical log

Low permeability reservoirs considered as tight gas reservoirs have been also detected in another gas field **„D"**, (eastern part of Transylvanian Basin) where the deeper Badenian units (IX and X) were tested with gas. The petrophysical parameters of these zones are presented in Table 3.

The next Figure 7 represents a fragment of the standard electrical log with cores, perforations and production tests.

We mention also that a **Minifrac** job was performed in the well D1, in 1995, resulting an increasing of flow rate from 25.000 .stcm/day to 53.000 stcm/day (+ 40 l salt water/day).

Based on these considerations, we can say that gas field **„D"** could be a good candidate for unconventional gas exploitation in deeper Badenian units.

Table 3

Zone	Porosity %	Permeability mD	Well	Tested interval m	Flowrate Stcm/day
Bn IX	**3–9***	**0.2–0.7 ***	**D_1**	**2352–2330**	**25.000 (the well is in production)**
Bn X	**2–6****	**0. 5 ****	**D_1**	**2440–2358**	**3000 (the well was produced)**

* – Parameters obtained from the core analysis: interval: 2334– 2338 = 4 m (Bn IX) – well **D1**

** – Parameters obtained from the core analysis: interval: 2373– 2377 = 4 m (Bn X) – well **D1**

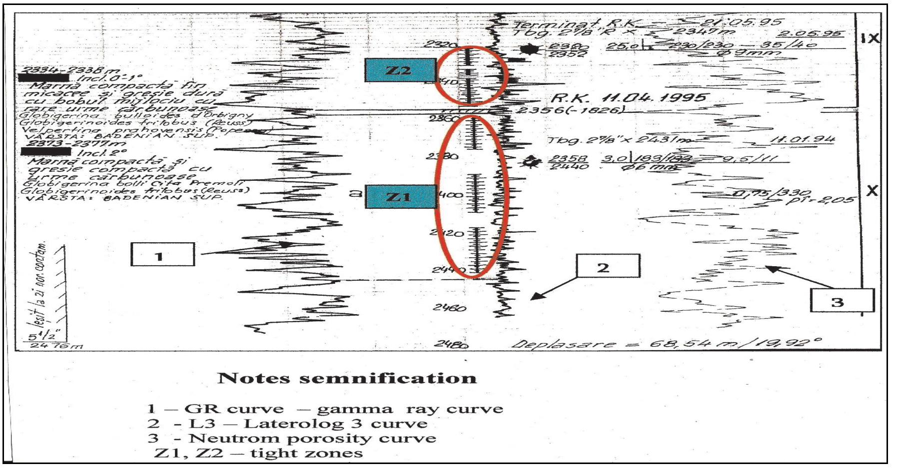


Fig. 7. Well D_1 – Fragment of the standard electrical log

The production tests performed in Badenian layers XIX – XX – XXI from **gas field**, **„E”** (central – southern part of Transylvanian Basin), represented by blocky sandstones with low permeability confirm the existence of gas in these tight formations. The Table 4 summarizes the petrophysical parameters of these tight zones.

These three layers are grouped together in one productive horizon Bn XIX + XX + XXI. Five wells produced from this zone and have been retrieved to upper layers and now three wells are in production.

The Figures 8, 9 and 10 illustrate the fragments of standard electrical logs, with perforated intervals and the obtained results.

The series of examples can continue with other gas fields from Transylvanian Basin, where tight gas formations were identified and which could be considered good candidates for tight gas exploitation. We can mention here gas fields located in different areas of Transylvanian Basin as: **„F”** (Bn XVI) (central part), **„G”** (Bn XII – Bn XIV, central – northern area) and **„H”** (Bn XV – Bn XVIII, central – eastern part).

Table 4

Zone	Porosity %	Permeability mD	Well	Tested interval m	Flowrate Stcm/day
Bn XIX	8–10*	0.1–0.2 *	E_1	2454–2382	22.000 (test)
Bn XX	7–9*	0.5–0.6*	E_1	2548–2474	Static pressure = 72/77 bar Zero flowrate (test)
	7–9*	0.5–0.6*	E_1	2550–2472 (reperforation)	Static pressure 125/134 bar q = 7000 stcm/day (test)
	6.7**	0.07**	E_2	2703–2651	46.400 (test)
Bn XXI	7–11*	0.4–0.7*	E_3	2778–2682	14.200 (test)

* – Parameters obtained from core analyses, petrophysical interpretation and geological modeling in **PETREL** (reservoir study/2010)

** – Parameters obtained from the core analysis: interval: 2687– 2689 = 2 m (Bn XX) – well $\mathbf{E_2}$

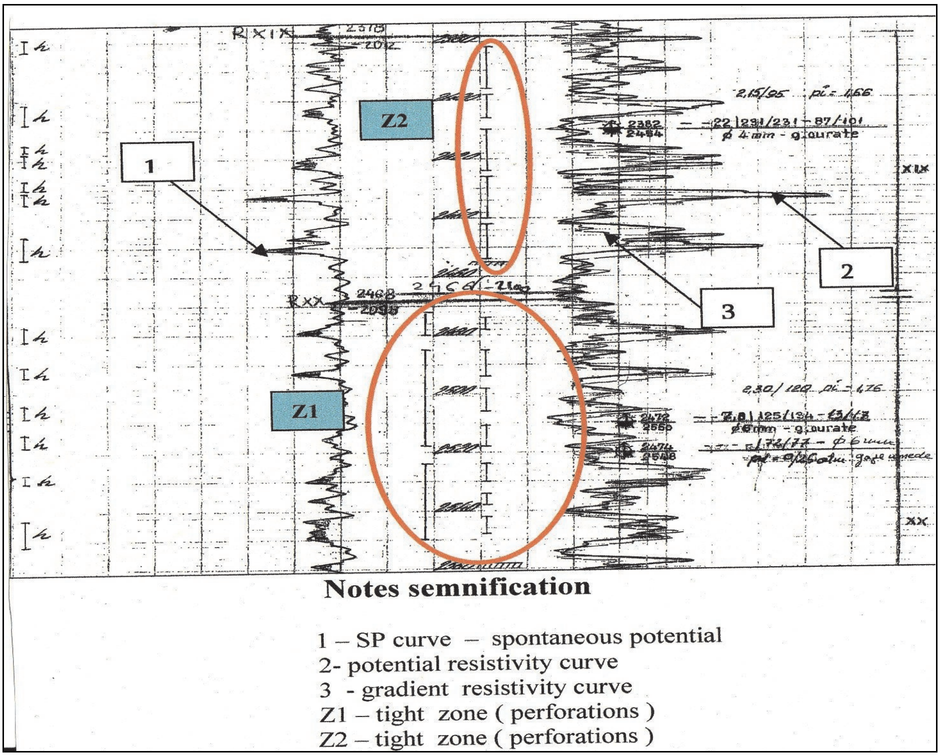


Fig. 8. Well E_1– Fragment of the standard electrical log

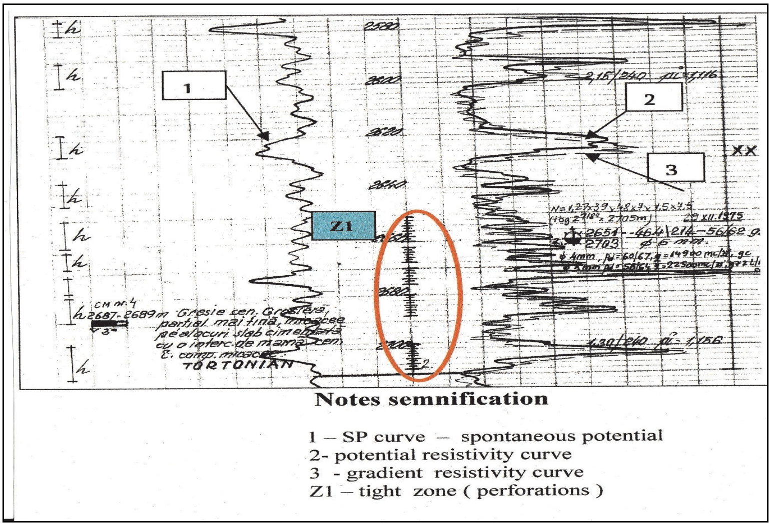


Fig. 9. Well E_2 – Fragment of the standard electrical log

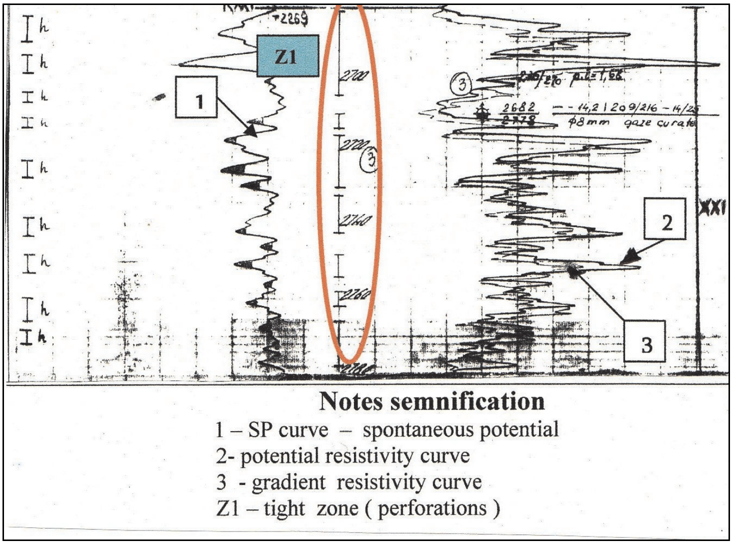


Fig. 10. Well E_3 – Fragment of the standard electrical log

4. CONCLUSIONS

From the above presented examples some conclusions and also few proposals could be emphasized:

– The existence of shale gas zones and tight gas formations in Romgaz gas fields is a certainty and is proved by different case studies presented in the paper;

– An increasing of productivity can be noticed after stimulation jobs as: minifrac, acidizing, reperforating;
– This paper represents the first Romgaz attempt to approach this topic and to perform a kind of assessment regarding the unconventional reservoirs;
– So far we didn't perform an inventory of the unconventional gas reservoirs, but it is possible to be done in the near future;
– Although it's very clear that extraction of natural gas from these reservoirs is more difficult and also more expensive than that from the conventional reservoirs, due to the new technologies which would be perhaps involved (hydraulic fracturing, acid jobs, etc.), we are fully convinced that what was considered unconventional in the past, will become conventional in the future.

REFERENCES

[1] Holditch A., Stephen Perry, K., Lee J.: Unconventional Gas reservoirs – Tight Gas, Coal Seams and Shales, Working Document of the NPC Global Oil and Gas Study, July 18, 2007

[2] ***** Romgaz archive