Petroleum and Coal

Article **Open Access**

Investigating Dynamic Analysis of Well Performance Producing from Turdaș Structure in Turdaș Gas Field Using a Production Logging Tool

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Received September 30, 2020; Accepted December 22, 2020

Abstract

In this paper, production logging was used to investigate the dynamic behavior of gas well performance. The recorded data of the PLT were used to diagnose five pay zones of well ATurdaș, located in Turdaș gas field, Romania. The fluid flow system is gas-liquid flow. There is also no production of oil. The main contribution of gas production with high rate and slug liquid-gas flow comes from the upper intervals 720-766 m. Flow regimes that appeared in the perforation intervals are slug gas-liquid, bubble, and single liquid flow. Producing water intervals are determined from 810-852m. Decreasing both temperature and pressure while moving upward are accompanied by increasing slip G-W, water, and gas velocities. The cement plug is recommended to block water till liquid level flow at 770 m.

***Keywords**: PLT; Water problems; Fluid characteristics; Dynamic analysis; Flow modeling.*

1. Introduction

A Production Logging Tool (PLT) is any device that is utilized to generate the production logs (PLs). The PLT is run down the wellbores in order to investigate and record the nature and behavior of formation fluids inside the well during production or injection. As soon as the PLs are constructed, evaluating wells production performance can be known by analyzing dynamic analysis at various production zones. Additionally, they are used to identify wellbore production problems through computing the fluids flow profile, the behavior of unwanted fluids, and flow regimes of the wellbore downhole. Furthermore, interpretation of the PL data provides fluid velocity profiles and contribution of each zone on total production. In order to optimize drilling and completion strategies for future wells and improve the productivity of existing wells, the provided PL data, and reservoir modeling are used [1-3].

A Technical Review of the PL and its Implementation is quietly discussed by expressing the history of the PLs, types, components, and their applications [4]. A technical review of the PLs and their tools, along with the variation for the horizontal well is also provided. Understanding the importance and technique of the PLs has become very effective. Further, innovative PLTs integrated with conventional production measurements were used in the Well Trigno 6 (located in San Salvo gas field) in Italy to diagnose water production problems [5]. All gas-producing wells in Italy have typology and problems similar to those of Trigno 6; therefore, this innovative and cost-effective solution was selected so as to control water production. Using a statistical approach and reviewing 350 PLs for oil and gas wells, binary Logistic models are developed in the Gulf of Thailand using to forecast the probability of success (POS) to detect water entry. The gas rate, oil rate, water rate, and the number of perforated sands were found to have a highly impact on the POS [6]. Moreover, two field examples were used to identify fluid types using an integrated approach composed of advanced PLTs and techniques in producing gas-condensate wells located in western Kazakhstan. The fluids of these wells are near the critical point on PT (Pressure-Temperature diagram) envelope [7].

Flow loop models are developed for two flowmeters so as to forecast well performance by utilizing production software of wireline [8]. Different PLs give ways to assess cased-hole well performance. The PLs are also used for detecting coning, cross fluid flow, fluid channeling, fluid flow profiles, and flow rates in production and injection wells [9]. Two examples of using the PL are presented to show the influence of a large volume, high rate acid on the reservoir pay zone during stimulation job and also their effect during the presence of formation water in the bottom of the pay zone interval [10].

In this paper, the PLT test was therefore performed in Turdas gas field based on the production department request after observing gas production reduction and water problems. It is wanted to determine which perforations produce water and which perforations produce gas. The PL data was analyzed, and the contribution of each fluid has been determined. Water problems have been diagnosed, and their intervals have been identified.

2. Analysis flow diagram

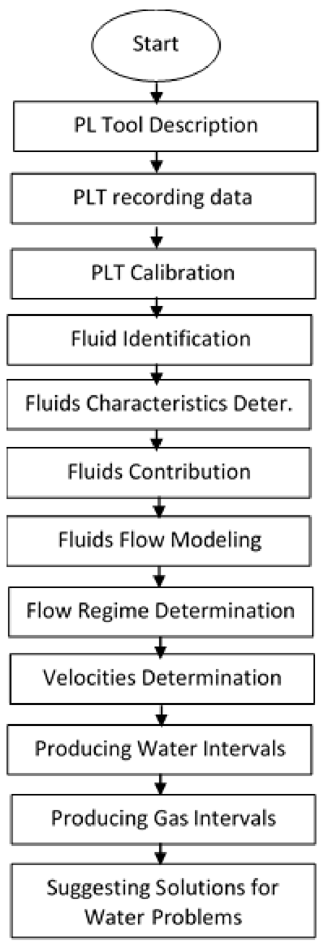


Figure 1 shows the flow diagram of methodology, which is used to analyze the dynamic performance of gas well A Turdaș in the southwestern part of the Transylvanian Basin. This methodology includes the stages to be followed in order to diagnose water production problems and the flow behavior in well.

3. Turdaș field description

The PL was carried out for well A Turdaș, a gas producer located in the Turdas gas field in northern Romania. The thrush structure is located in the southwestern part of the Transylvanian Basin. The Turdas structure was put into production in 2004 by 4 wells, and currently, it still produces a flow of 4 thousand N m^3/day through these 4 wells. Well A has a flow of 2.1 thousand Nm^3/day. Table 1 shows the cumulative production from the production until today on each section of the analyzed well A with PLT. Briefly, the geological data about the Turdas gas field can be simplified and described. The drilled wells in the Turdas structure were opened in the Upper Sarmatian, Bulgovian, and Badenian formations. The Sarmatian has a thickness of 250 meters and was opened by all the wells on the structure and consists of compact marls and sandy marls with intercalations of sandstones and sands. The Bulgovian is between 500 and 800 meters thick and consists of compact marls, sometimes sandy or clayey, with thin intercalations of sand and well-cemented sandstones.

Figure 1. Methodology flow chart

Table 1. Production of well ATurdaș.

Section name	Well	Period	Interval (m)	Cumulative production (Mm^3)
X(BI.A)	6	11/2004-08/2014	850-854	4.53
X(BI.A)	6	08/2014-03/2019	720-854	1.81
V+VII(BI.A)	6	03/2019-09/2020	432-636	0.84

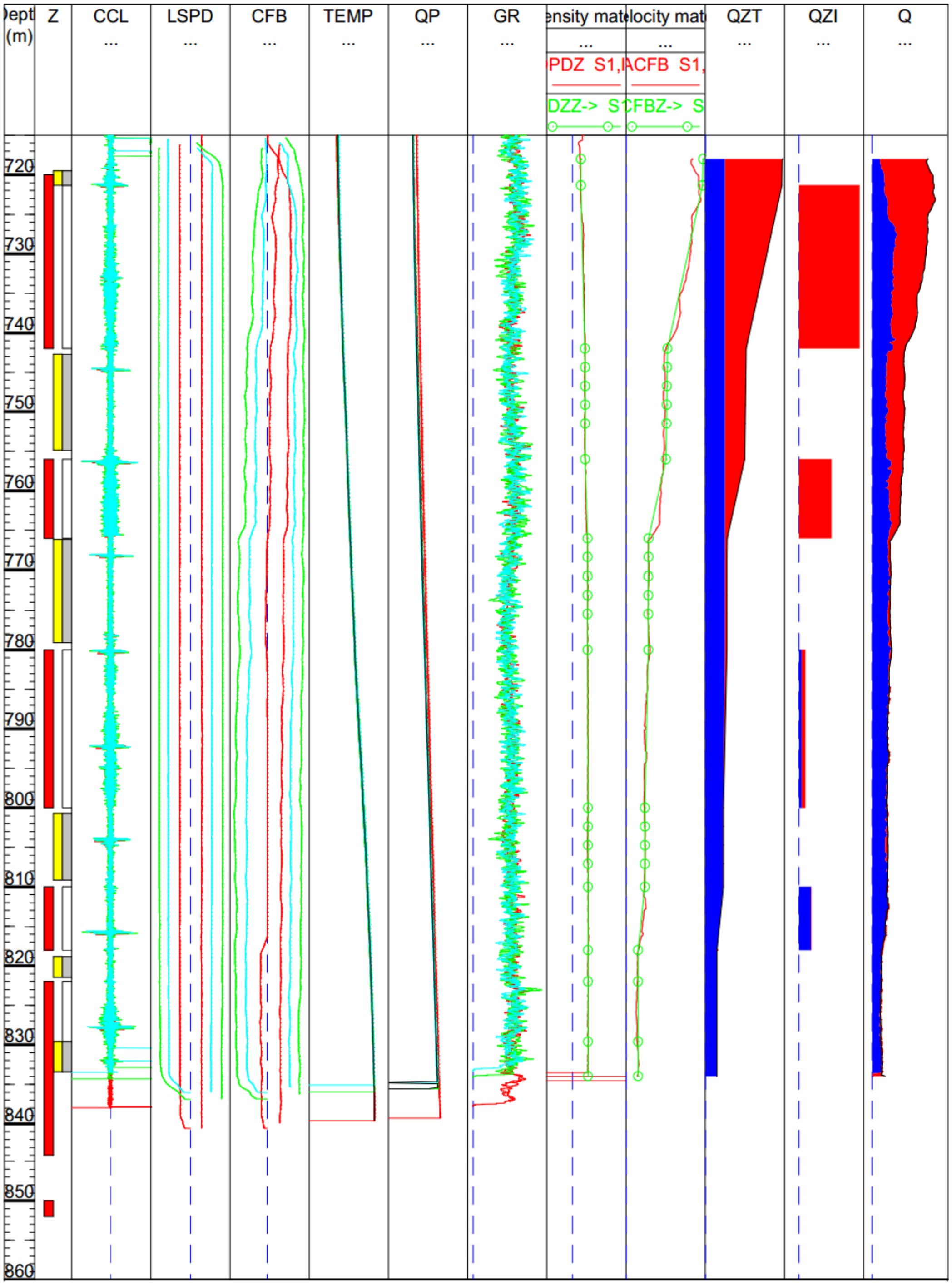
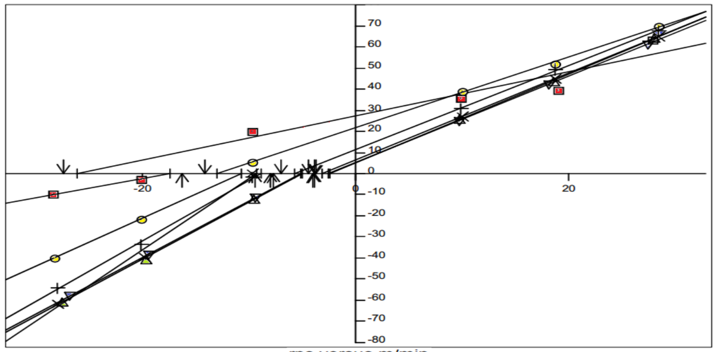


Figure 2. PLT recorded data for well ATurdas

The Upper Badenian has a thickness between 800 and 850 m was opened by a probe that collected salt at a depth of 850 m. Following the interpretation of the seismic data, structural images were drawn up, which shows that the structure is in the form of an NV-SE-oriented hemianticlinal. The PL was performed with a dynamic survey during well production of surface rates of gas 2.275 Mm3/d, oil 0 Mm^3/d, and water 0.003 Mm^3/d. The PL tools are the string of OD 42.8625 mm, spinner blade of OD 53 mm, and calculated pseudo density. Figure 2 shows the recording data of the PL, such as pressure, temperature, gamma-ray, casing collar locator, and fluid flow rate.



rps versus m/min

Threshold (+) 1.25 m/min   Threshold (-) -1.25 m/min

	Calib. Zone m	Slope (+)	Slope (-)	Int (+) m/min	Int (-) m/min	Int. Diff. m/min
■	719.5- 721.3	1.043	0.918	-26.12	-17.42	-8.70
○	742.7- 754.9	1.680	2.269	-12.90	-10.64	-2.26
+	766.2- 779.1	1.999	2.879	-5.71	-8.87	3.16
×	800.7- 809.2	2.067	3.381	-3.09	-9.24	6.15
▲	818.8- 821.5	2.104	2.715	-2.45	-5.04	2.59
▼	829.6- 833.4	2.045	2.686	-2.60	-5.19	2.59

Figure 3. The continuous flowmeter calibration of PLT for well A Turdaș

Table 2. Fluid contributions by phase

Zones (m)	Qt res. (m³/d)	Production (%)	Qw res. (m³/d)	Qo res. (m³/d)	Qg res. (m³/d)	W O G
721.3-742	168.82	54.13	0.00	0.00	168.82	
756-766	91.19	29.24	0.00	0.00	91.19	
780-800	17.93	5.75	7.64	0.00	10.30	
810-818	33.93	10.88	33.03	0.00	0.89	
822-844	0.00	0.00	0.00	0.00	0.00	
850-852	Blocked					

Table 3. Total rates by phases

Zones (m)	Corr. factor	Vm (m/min)	$Q_{downhole}$ (m³/d)	Contrib (%)	Qw res. (m³/d)	Qw SC. (m³/d)	Qg res. (m³/d)	Qg SC. (m³/d)	Qo res. =Qo SC.
721.3-742	0.84	21.154	387.71	54.13	98.34	9.79E-2	289.37	3.69	0.00
756-766	0.83	11.049	202.50	29.13	98.36	9.79E-2	104.14	1.55	0.00
780-800	0.82	5.988	109.74	5.75	98.38	9.79E-2	11.36	0.21	0.00
810-818	0.82	5.002	91.68	10.88	90.79	9.02E-2	0.89	4.37E-2	0.00
822-829.6	0.81	3.152	57.76	0.00	57.76	5.74E-2	0.00	1.77E-2	0.00

Table 4. Gas and water physical characteristics

Zones (m)	ID (mm)	Devia-tion, º	Rt	T (°C)	P (bara)	βw	μw (cP)	Rhow(g/cc)	βg	μg (cP)	Rhog (g/cc)
719.5-721.32	127	0.00	0.00	33.7	13.365	1.0056	0.9573	1.06	0.0787	o.0119	0.009
742.7-754.9	127	0.00	0.00	34.5	15.460	1.0058	0.9421	1.06	0.068	0.0119	0.0104
766.2-779.1	127	0.00	0.00	35.4	17.612	1.0060	0.9267	1.06	0.0597	0.0120	0.0119
800.7-809.2	127	0.00	0.00	36.9	20.908	1.0065	0.8995	1.05	0.0503	0.0121	0.0141
818.8-821.5	127	0.00	0.00	37.5	22.494	1.0067	0.8891	1.05	0.0467	0.0122	0.0152

***No values for oil due to its absence, i.e., βo=N/A, μo=N/A, and Rhoo=N/A for all intervals*

Table 5. Flow regimes and their velocities profile

Zones (m)	Correl G-W	Correl O-W	Regime Pattern	V_{Slip} G-w (m/min)	ɣw	Vw (m/min)	ɣg	Vg (m/min)
719.5-721.32	Dukler	N/A	Slug liquid-gas	23.468	0.53	10.10	0.47	33.60
742.7-754.9	Dukler	N/A	Slug liquid-gas	23.468	0.810	6.62	0.19	30.10
766.2-779.1	Dukler	N/A	bubble	18.276	0.97	5.51	0.0261	23.80
800.7-809.2	Dukler	N/A	bubble	18.282	1.00	4.96	0.002	22.70
818.8-821.5	Dukler	N/A	Single phase liquid	0.000	1.00	3.15	0.00	0.00

***No values or patterns for O-W due to oil absence i.e no flow regime, no slip* velocity, ɣo=N/A, and Vo=N/A

4. Results and discussion

Firstly, the PLT records data through a device called Flowmeter. The flowmeters take readings within perforated intervals. These readings may be affected by the local turbulence and hence effect on the data used for doing the dynamic analysis of well. Therefore, the Flowmeters should be calibrated by an in situ technique in order to obtain the data accurately. This technique is done through recording the tool's response in revolutions per second (rps) while moving, both up and down, at numerous specific absolute velocities within column fluid movement. Based on these recordings, exact relationships can be constructed between the tool rps and fluid velocity in m/min (Figure 3). Therefore, the logs contain both their own calibration data and the data required for making analysis.

Fluid type identification is the first step of the PLs. From Figure 2, the fluid system is the two-phase flow of Gas-Water (G-W), and there is no Oil-Water (O-W) flow or three-phase flow of G-O-W. The existing gas has a specific gravity (ɣg) of 0.58 and zero percent of impurities. In order to compute gas compressibility factor (Z) and viscosity (μg), Beggs and Brill correlations and Lee *et al.* correlations are used, respectively. For water phase flow, it has 80000 ppm salinity. To determine water properties, Katz correlation, Dodson and Standing correlation, and Van-Wingen and Frick correlations are selected for calculating gas-water solubility (Rsw), water compressibility (Cw), and water viscosity (μw), respectively.

Dynamic analysis was done for well A Turdaș, and the results appear in Tables 2 through 5. Clearly, it is observed that there is no production for oil from this well and the only existing production fluids are gas and water. In order to build a flow model, the Dukler correlations are selected. Dynamically, it was found that Pd = 4.9/0 bar P1/2 = 4.9/1 bar with Nozzle =6 mm and Imp = 0/12 h of the pay zone interval 0-841m. Additionally, the dynamic fluid level of liquid was found at 770 m with a gas rate of 3.67 Mm^3/d and zero water rate. From the analysis of the curves of Pressure, Temperature, Density, Flow, Natural ɣ-ray, casing collar locator, the analysis results (Tables 2 through 5) were obtained for perforations depths. Details of fluid contributions, fluids rate, and fluid flow modeling are presented in Tables 2 through 5. The main contribution of gas production with high rate and slug liquid-gas flow comes from the upper intervals 720-766 m. Going to downhole the bottom zones, the contribution of gas decreases, the flow regime turns to bubble flow, and the production of water appears until reaching the blocked interval 850-852 m passing through single-phase liquid flow in 810-852 m. Decreasing both temperature and pressure while moving upward are accompanied with increasing slip G-W, water, and gas velocities (Table 4&5).

5. Conclusions and recommendations

The obtained results produce the dynamic analysis of well A Turdaș, and it is found that water comes from the lower perforations, and gas is produced from the upper perforations. Consequently, the lower perforations that produced water must be isolated. Following the isolation operation of the perforations that produced only water, the gas flow increased, and the well would not produce any water. In addition to the previous conclusions, plugged perforations are 841-844m and 850-852 m. The amount of water is also produced by the perforation intervals 810m-818m and 822m-841m. Finally, the proposed solution for isolation of perforations at 810m-818m, 822m-844m, and 850m-852m is using a cement plug at 770 m. The proposed program was carried out by isolating the intervals that produced water with cement plug at 770 meters with the following parameters:

- Static pressure after intervention 42/44 bar.
- Dynamic pressure Ø7 mm = 10/10.2 or 10/9.3 and Q = 4.07 Mm^3/d, entrained impurity zero liters.

Apparently, the operation was successful; the well no longer causes liquefaction, also gas production increased

Nomenclatures

QZXT stands for total rate, where Z stands for zoned, X is a letter representing the phase: O=Oil, G=Gas, W=Water, and T stands for Total
QZXI stands for incremental, where Z stands for zoned X is a letter representing the phase: O=Oil, G=Gas, W=Water, and I stands for Incremental
QZXTR stands for cumulative ratio, where Z stands for zoned X is a letter representing the phase: O=Oil, G=Gas, W=Water, T stands for Total, and R stands for Ratio

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