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Drilling of the First Horizontal Well in Western Turkmenistan

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ABSTRACT

Currently, the study of early horizontal drilling operations in Western Turkmenistan is of renewed interest, as it represents one of the first technological milestones in the region's petroleum engineering history. The development and analysis of horizontal well drilling techniques in the early 1990s provided valuable insights into the practical implementation of new directional drilling technologies under complex geological and pressure conditions.

This study presents a detailed technical and historical analysis of the first horizontal wells drilled in the Koturdepe field between 1990 and 1992. The paper examines the well design, drilling assemblies, drilling fluids, and directional control systems used, and evaluates their technical performance and economic impact. Unlike a purely historical report, this work emphasizes the scientific and engineering lessons learned from these early operations and discusses their relevance to modern drilling practices in Turkmenistan. The research also includes an economic comparison between horizontal and vertical wells, demonstrating how the initial cost premium of horizontal drilling was offset by significantly higher productivity.

The results are of practical importance for optimizing drilling technologies in fields with abnormally high reservoir pressures and for applying these lessons to modern digital drilling systems.

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1. Introduction

Horizontal drilling has become a defining technology in the development of oil and gas fields worldwide. Its implementation in Western Turkmenistan during the early 1990s marked a significant milestone in the regional petroleum industry, providing valuable experience under unique geological and technical conditions [1-3].

The introduction of horizontal wells in Turkmenistan enabled the de-compaction of well patterns, significant reduction in capital investment for drilling and surface infrastructure, and, through the extension of drainage channels, a several-fold increase in production rates from tight and low-permeability formations [4, 5].

At the time of these operations, horizontal drilling was a relatively new and experimental approach in the region. The work carried out by the Turkmenneft Production Association between 1990 and 1992 at the Koturdepe field represented one of the earliest successful applications of this technology in the Caspian Basin [6, 7].

This case study not only reflects the technical aspects of early horizontal drilling but also provides insight into the evolution of drilling practices, from conventional mechanical systems to modern downhole electric motors (DEMs) and automated control systems [8-10]. Today, revisiting these pioneering projects has renewed relevance.

Understanding the successes and limitations of these early operations helps to:

- assess the technological maturity and decision-making frameworks of that period,
- evaluate the performance of drilling assemblies and fluids under abnormal pressure conditions, and
- identify transferable lessons for current drilling practices in the oil and gas fields of Turkmenistan and other regions [11-13].

The purpose of this paper is therefore twofold:

1) to document the design, execution, and outcomes of the first horizontal wells drilled in Western Turkmenistan, and

2) to analyze the scientific and engineering implications of these operations, highlighting their influence on modern horizontal well development [14, 15].

2. Materials and Methods

2.1. Well Design

The drilling of the first horizontal wells in Western Turkmenistan was carried out by Turkmenneft Production Association between 1990 and 1992 at the Koturdepe field, where three wells (Y1, Y2, Y3) were successfully completed [16, 17].

The average total depths were 3653 m, 3606 m, and 3603 m, respectively. Well Y1, drilled in March 1990, was the first horizontal well constructed in the region [18]. Its design aimed to test the feasibility of drilling through the red-colored strata of horizon NK7 under abnormal pressure conditions. The horizontal section length was 230 m, with a total deviation of 260 m at an azimuth of 270°, and a maximum inclination angle of 86.3° (Fig. **1**).

1. - Vertical section: 2,3,5,9 - Accordingly, “Shoes” of the conductor. I- Intermediate. II - Intermediate and production columns: 4 - Section of the inclination rise up to 220: 6 - Section of the inclination rise up to 86.30: 7.12 - Stabilization sections of the inclination angle: 8 - Section of the decline in the inclination angle: 10.11 - Top and bottom of the productive formation. The casing program was designed in accordance with the specific requirements of horizontal drilling technology (Table **1**).

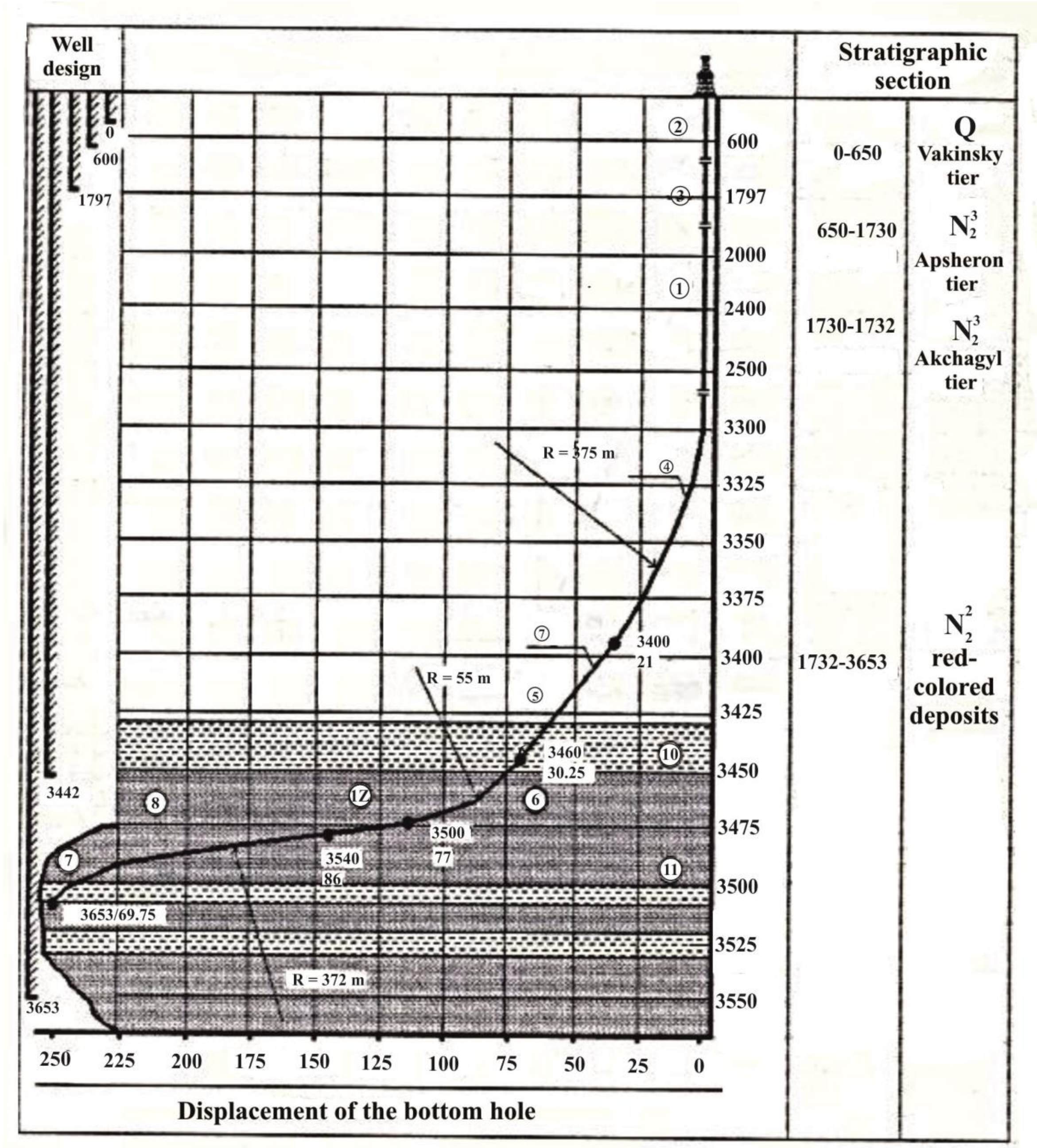

Figure 1: Vertical projection of the profile and design of wells Y1 Koturtepe “West”.

Table 1: Well design for drilling well No. Y1.

Column Name	Column Diameter, mm	Column Running Depth	
		Design	Actual
Direction	630	5	5
Direction	530	30	30
Conductor	426	600	600
I intermediate column	324	1800	1797
II intermediate column	245	3200	3442
Production casing	140	3750	3653

The intermediate strings were lowered to the top of the NK7 horizon to ensure stability and safe deviation operations. The actual setting depth of the second intermediate string was later adjusted according to the encountered geological conditions [19, 20].

2.2. Drilling Assemblies

Drilling operations were performed using downhole electric motors (DEM), referred to in the original text as "electric drills". These systems, such as models E290-12AMV5 and E240-8MV5, converted electrical energy transmitted from the surface into mechanical torque at the bit, enabling precise directional control without complex surface rotary systems.

The applied electrical system included a TMEB-630/6 transformer, UZEB-83 control and protection device, TE-2MV5 pantograph, UKI insulation control unit, and KST1-TG current leads. The drilling assemblies and measurement systems allowed effective monitoring of current, voltage, and motor performance in real time [21-23].

The spatial trajectory of the well was controlled using serial telemetry systems 1STE215-UZ and 1STE164-UZ, coupled with surface control panel PN-ZMZ, which provided digital readouts of inclination, azimuth, and drilling parameters.

Additional centralizers and stabilizers ensured borehole quality, maintaining a minimum diameter of 257.5 mm with an effective borehole diameter of 267.5 mm.

2.3. Drilling Fluids

One of the most critical engineering decisions during drilling was the change of drilling fluid type [24]. Initially, a lignosulfonate-based mud was used; however, it was later replaced with a polymer-potassium silicate drilling fluid, chosen for its superior lubricity, borehole wall stabilization, and cuttings transport properties.

This fluid exhibited:

- enhanced lubricity, reducing pipe-wall friction,
- increased near-wellbore strength to prevent collapses,
- improved solids-carrying capacity, and minimal damage to the reservoir's productive zones [25, 26].

The change in fluid system played a decisive role in the successful completion of the horizontal section, confirming the effectiveness of polymer-based muds in over pressured formations.

2.4. Directional Control and Deviation Operations

The planned deviation started from a depth of 3385 m, with the zenith angle gradually increased to 22° at 3400 m. To achieve the designed curvature, a D-172 downhole motor with a 2° bent sub and adjustable curvature mechanism (OSh-172) was used. Due to the high angle build-up rate (up to 12.5° per 10 m), the actual curvature radius was reduced to 50 m, smaller than the designed 80 m. This deviation required continual adjustment of the well profile and drilling assemblies [27, 28].

Throughout the operation, real-time data from downhole instruments guided adjustments in inclination and azimuth, marking one of the first uses of a semi-automated telemetry-guided drilling system in Turkmenistan [29].

Cementing operations were carried out using a PDM-140 collar packer, ensuring complete zonal isolation. Filter pipes (140×9.17 mm, R110) with five pre-drilled helical perforations per meter were installed at the production interval (3446–3653 m).

3. Results and Discussion

The results of processing the field data demonstrated that the wellbore of Y1, drilled to 3653 m, successfully penetrated the upper layer of the NK7 horizon [30, 31]. The design and operational approach proved effective under abnormal pressure conditions, providing valuable lessons for subsequent horizontal drilling operations.

Casing string 140×146×168 mm, equipped with PDN-140, was run without complications. Cementing through the collar packer was executed for the first time in local practice, ensuring full integrity and zonal isolation of the production section.

After replacement of the drilling mud with a polymer–potassium silicate system, the well achieved a stable and clean borehole, resulting in a high-quality cement bond and excellent reservoir preservation.

When switched from mud to water during well testing, the initial production rate reached 135 tons/day, compared to an average of 25 tons/day for nearby vertical wells in the same NK7 horizon — a fivefold increase in productivity.

The drilling of the horizontal section (3450–3653 m) took 131.5 hours of mechanical drilling time, demonstrating high operational efficiency for that period [32-34].

3.1. Technical and Operational Performance

The optimized design and configuration proved universal and applicable to other wells in the Koturdepe region. The operation validated the feasibility of horizontal drilling using existing electric motor systems and telemetry instrumentation [35, 36].

The performed analysis of well construction parameters confirmed that the applied casing program and bottom-hole assemblies ensured achievement of the target horizon [37]. Table **2** summarizes the main well design characteristics.

Table 2: Well design parameters for Y1 Koturdepe.

Column	Diameter, mm	Descent Depth, m
Direction	630	5
Direction	530	30 – 50
Conductor	426	600
Intermediate:		
the first	324	1550 – 1800
the second	245	3350 – 3450
operational	140	Actual depth

Column:	Electric drills type:
Conductor	
Diameter 426 mm – 600 m	E290 - 12AMV5 with a reduction gear - insert (RI = 3)
Intermediate column:	
first	E290 – 12AMV5 (RI=3)
Diameter 324 mm – 1800 m	
second	E240 – 8MV5 (RI=3)
Diameter 245 mm – 3450 m	E240 – 8MV5 (RI=3) with a curvature mechanism CM -1, MI-1.5.
	E164 -8P (RI=3) with 2 curvature mechanisms
Production casing:	CM-1x1.5 CM-1x1.5.
diameter 140 - up to the actual depth	E164 - 8MI5 (RI = 3)

The geological section comprised alternating sandy–clayey rocks with two unstable clay members (“black clay”) totaling about 150 m in thickness. Despite these challenges, borehole stability was maintained through the use of polymer-based mud and adjusted drilling parameters [38].

3.2. Economic Evaluation

A comparative economic analysis was carried out between the horizontal and vertical wells drilled in the Koturdepe area during 1989–1991 [39].

The data presented in Table **3** indicate that although the cost per meter of horizontal drilling (598 rub/m) was approximately 1.95 times higher than that of vertical wells (306 rub/m), the productivity per well increased more than fivefold.

When normalized per ton of daily production, the unit cost of horizontal wells (126 rub/t) was significantly lower than that of vertical wells (383 rub/t).

This demonstrates that the higher initial drilling cost was economically justified by the substantially greater yield [40].

Additionally, the total drilling time increased only by 70%, while the production gain exceeded 400%, resulting in a net economic efficiency ratio of 1:5.7.

Table 3: Technical and economic indicators and calendar time balance for comparable wells 3650 m deep drilled by electric drills in Koturdepe management of drilling operators for 1989-1991.

Indicators	Electrical Drilling		Ratio of Indicators in%
	Vertical (XY1, XY2, XY3, XY4, XY5, XY6, XY7, XY8)	Horizontal (Y1, Y2)	
Drilling target	Operation		
Square	Kotur-Depe		
The number of compared wells	8	2	
Average well depth, m	3655	3630	100,7
Number of bits, units	67,4	64,5	
Drilling on a bit, m	54,2	56,3	96,3
Mechanical speed, m/h	4,8	4,67	102,8
Cruising speed, m/h	2,72	2,64	103,0
Technical speed, mst-month	670	497	134,8
Commercial speed, mst-month	618	358	172,6
Actual costs for 1 well, rub.	1119564	2171375	
cost of 1 m of penetration, rub.	306,31 h %	598,17 h %	51,2
balance of calendar time	4258 100,0	7308 100,0	
Total calendar time	1342 31,5	1373 18,8	
Sinking works	761 17,9	777 10,6	
Incl. mechanical drilling	513 12,0	517 7,1	
descent - ascent	68 1,6	79 1,1	
build-up	874 20,5	1148 15,7	
Fastening			
Preparatory and auxiliary work	1157 27,2	1881 25,8	
		858 11,7	
Renovation work	323 7,6	223 3,0	
Incl. search for insulation breakdowns	110 2,6	- -	
Complications	233 5,5	5260 72,0	
Total production time	3929 92,3	1497 20,5	
Accidents and defects at work	15 0,3		

Therefore, even within the technological limitations of the early 1990s, horizontal drilling provided superior returns on investment in the context of Turkmenistan's oilfield development [41, 42].

3.3. Interpretation of Table 3 Data

The comparative data in Table **3** reveal several key insights:

1. The mechanical penetration rate of horizontal wells was nearly identical to that of vertical wells (4.67 m/h vs. 4.8 m/h), confirming that the use of downhole electric motors maintained operational efficiency.
2. The total calendar time increased mainly due to additional directional control and cementing operations, but this did not critically affect overall project timelines.
3. The dramatic improvement in oil production from 25 to 135 tons/day directly compensated for the additional costs.

Hence, the horizontal wells demonstrated both technical and economic feasibility, forming the basis for future expansion of the method across Western Turkmenistan [43, 44].

3.4. Modern Relevance and Technological Lessons

Although these operations took place over three decades ago, their lessons remain directly relevant [45, 46].

The key takeaways include:

- validation of downhole electric motor (DEM) technology for precise directional control,
- confirmation of the effectiveness of polymer drilling fluids in unstable formations,
- establishment of a casing and cementing workflow for high-angle boreholes, and
- demonstration of long-term economic viability of horizontal completions in abnormally pressured reservoirs [47, 48].

Modern drilling operations using rotary steerable systems, machine learning–assisted trajectory control, and real-time downhole telemetry are direct descendants of these early experiments.

The experience from Koturdepe thus represents an important technological foundation linking past field operations with current digital drilling methodologies [49, 50].

4. Conclusions

The drilling of the first horizontal well in Western Turkmenistan (Well Y1, Koturdepe field) represented a pioneering achievement in the regional oil and gas industry. The study demonstrates that the technologies applied in the early 1990s-despite their experimental nature—proved technically viable and economically efficient.

The main conclusions of this work are as follows:

1) Technical Feasibility: The design and construction of Well Y1 confirmed that horizontal drilling could be successfully implemented using existing downhole electric motor (DEM) systems and standard surface electrical infrastructure, without requiring major imported technologies.

2) Fluid Optimization: Replacing lignosulfonate mud with a polymer–potassium silicate drilling fluid significantly improved borehole stability, lubricity, and reservoir preservation. This approach remains relevant for today's over pressured formations with unstable clay sections.

3) Directional Control: The integration of real-time telemetry (1STE215-UZ, 1STE164-UZ) for trajectory monitoring was one of the earliest examples of semi-automated wellbore control in Turkmenistan. This laid the groundwork for later adoption of rotary steerable systems and modern automated drilling.

4) Economic Performance: Although horizontal drilling initially required higher capital costs, its productivity exceeded that of vertical wells by more than five times, making the overall operation economically advantageous.

5) Technological Recommendations: Based on this case study, several practical improvements are recommended for modern operations in similar geological conditions:

- further use of low-damage polymer-based muds to maintain reservoir integrity,
- application of downhole telemetry and machine-learning-based trajectory optimization systems,
- optimization of casing programs for minimizing non-productive time during deviation and cementing, and
- extension of horizontal section lengths to enhance drainage area coverage.

The engineering insights gained from this historical operation remain directly applicable to present-day drilling strategies in Western Turkmenistan. They demonstrate that systematic optimization of well design, drilling fluids, and downhole control systems can substantially improve both technical efficiency and economic performance.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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