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GEOLOGICAL AND DRILLING ASPECTS OF COLUMBIA'S MINGO COUNTY PROSPECT

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Columbia Gas Transmission Corporation's Well 9674-T was located and drilled on the North Kermit Prospect on Mineral Tract No. 10, in Harvey District, Mingo County, West Virginia. (See Fig. 1).

The North Kermit Prospect is situated on the south flank of the Rome Trough in association with a major northeast-southwest trending down-to-the-north basement fault (see Fig. 2). It was anticipated that a southern platform, located south of the major fault would have been exposed to erosion during the formation of the trough resulting in deposition of clastic units adjacent to and north of the fault. These units would then have acted as reservoir beds. This supposition was based on seismic data, structure and stratigraphy observed along the northern hinge line.

Well 9674-T had as its primary objective the testing of the Rome and Basal Sand formations with a secondary objective of testing all units below the Tuscarora Sandstone.

Seismic data indicated structural closure of 600 feet against the fault on the basement surface. A closure of 200 feet was indicated near the top of the Rome.

The Rome was expected to contain massive marine sandstones with interbedded dark shales and some limestones. Both lenticular and blanket type sands were expected north of the fault, affording structural and stratigraphic possibilities, with maximum sand development along the fault scarp. The well was spudded on September 30, 1971, and was the first of several wells which have since been drilled to basement within the deeper portion of the Rome Trough.

The well was drilled by Loffland Brother's Rig 111 which is capable of drilling below 20,000 feet (see Fig. 3). Rig 111 was located near Laurel, Mississippi, and it required 14 days to move to the location.

Due to terrain, the well site was 140 x 200 feet, rather than the recommended 400 x 400 feet. The location was surrounded on three sides by a creek which could not be relocated. The adverse terrain seriously

hampered the location size and flexibility.

All reserve pits were located across the creek from the location. This necessitated pumping all waste fluids rather than utilizing gravity flow into the reserve pits. Building the location and rigging up required 30 days.

This being the first deep test to be drilled by Columbia Gas, and the only deep well being drilled in the area at that time, created severe problems with logistics. Much of the required material for drilling this well was not available locally and therefore was transported from the southwest. This created high transportation costs and a considerable amount of rig waiting time.

Air was used as the drilling medium when possible. The available air consisted of five Chicago Pneumatic primary compressors driven by Caterpillar D-379 engines rated at 1000 CFM each @ 250 PSIG and two Chicago Pneumatic compressors driven by Caterpillar D-379 engines with a rated capacity of 2000 CFM @ 1250 PSIG. The Compressors were attended 24 hours per day by qualified personnel.

A 28-inch hole was drilled to 32 feet and 26 inch drive pipe was set (see Fig. 4).

A 17-1/2 inch hole was drilled to 1,664 feet and reamed to 24 inches. This required 74 days including a 21 day fishing job for a 24 inch bit. While drilling the 17-1/2 inch hole air circulation was lost at 1,225 feet and three attempted squeeze jobs failed to correct the lost circulation. The hole was drilled on mud from 1,225 feet to 1,660 feet. A string of 20 inch, 133 lbs./ft., K-55 STC casing, weighing 219,000 pounds was set at 1,645 feet and cemented to surface.

It required 29 days to drill a 17-1/2 inch hole to 6,157 feet with air. A string of 13-3/8 inch, 72 lbs./ft., N-80 STC casing was set at 6,104 feet and cemented to surface utilizing a two stage cement tool. This string of pipe was run in a dry hole and weighed 440,000 pounds. An OCT casing pad and 5000 psi casing head was welded to the 13-3/8 inch casing. At this time the preventer stack which consisted of one Cameron Type U, 13-3/8 inch, 10,000 psi WP double, one Cameron Type U, 13-3/8 inch, 10,000 psi WP single, and one Shaffer 13-3/8 inch, 5000 psi WP Annular type preventer was installed.

Drilling was continued with air in a 12-1/4 inch hole and drilled to 10,960 feet. Prior to running 10-3/4 inch casing the hole was mudded up. The 10-3/4 inch was set @ 10,902 feet and consisted of 7,101 feet of 65.7 lbs./ft., P-110 with a Super Hydril Flush Joint connection and 3,801 feet of 60.7 lbs./ft., P-110 Buttress casing. The string was cemented to surface with a two stage cement job. Drilling was continued on air with a 9-1/2 inch hole to 13,057 feet where gas and salt water were encountered. Upon encountering the gas and salt water, the drill pipe parted and stuck. Approximately 1-1/2 hours later the salt water and gas flowed to the surface. This kick was encountered while drilling with air and was, in terms of pressure, if not the largest, one of the largest ever encountered in the world.

The well was then killed with 10.1 lbs./gal. mud and a free point indicated the drill pipe was stuck at 9,850 feet. While washing over the bridge another kick was taken which required 18.1 lbs./gal. mud to kill. After fishing for 52 days, a decision was made to log the hole and sidetrack. Logs showed the hole to be deviated 22° @ 12,800 feet. A fish 175 feet long was left in the hole at 12,863 feet. A cement plug was set from 12,420 feet to 12,000 feet. This first plug did not harden. Therefore, a second plug was set from 12,289 feet to 11,879 feet and the hole was successfully sidetracked. This fishing and sidetracking operation required a total of 103 days to get back to the original depth at a cost of $811,000. The new hole was a horizontal distance of 133 feet from the old hole. Prior to drilling through the high pressure zone the mud weight was increased to 18.2 lbs./gal. in anticipation of a kick. However, while drilling through this zone no drilling break was encountered and subsequent logs indicated no porosity at that depth. While drilling from 13,057 feet to total depth several gas shows were encountered. Only one of these shows warranted a drill stem test. At a depth of 14,369 feet a drill stem test was run and proved the show to be of noncommercial quantities.

A core was cut from 16,201 feet to 16,260 feet. The well was then drilled to 16,338 feet where a liner was set from 10,670 feet to 16,337 feet. The liner consisted of 7-5/8 inch, 39 lbs./ft., S-95 Super Hydril Flush Joint and was set with a Texas Iron Works Hanger.

Drilling continued below the liner with a 6-1/4 inch bit. Another core was cut from 17,906 feet to 17,915 feet. The liner was drilled out with 17.0 lbs./gal. to 17.1 lbs./gal. mud.

After drilling to 18,554 feet, a tight hole was encountered and the drill string would not go below 18,031 feet. A cement plug was set from 17,600 feet to 18,020 feet, but was not hard enough to kick off. A second cement plug was set from 17,906 feet to 17,300 feet. The hole was successfully sidetracked and drilling resumed.

While drilling below the liner the mud weight was gradually lowered to 16.0 lbs./gal. (see Fig. 5). The rotating hours were 38.7% which is low (see Fig. 6). Approximately 15.5% of the time was spent in fishing, mudding up and well control which was excessive. The majority of this time may be attributed to the kick taken while drilling on air at 13,057 feet. At 10.7%, the rig repair and miscellaneous time was excessive and may be attributed to an ineffective preventive maintenance program by the Contractor.

The total time from spud date was 504 days and the cost of the well was $4,000,519.

Formations from the surface to the Conasauga Shale-Rome Formation contact showed a general thickening reflecting the general southeastward regional dip (see Fig. 7).

The major change takes place at the Conasauga-Rome contact. In the Inland Gas Company Well No. 542, 39 miles northwest, the Conasauga-Rome are lumped as one shale unit 250 feet thick, overlying 4,130 feet of Tomstown and 610 feet of Basal Sand. United Fuel Gas Company's Well U-8610-T, 20 miles west, encountered 240 feet of Conasauga overlying a drill section of 4,558 feet of Rome. This well was TD-ed without drilling the entire Rome section. Compare these wells to 9674-T, which drilled 306 feet of Conasauga overlying 8,687 feet of Rome. The Rome comprised 44% of the Rock section drilled.

The Rome was made up of the following lithologic units from its top at 10,840 feet:

290' Gray to greenish-gray shale, silty in part.

170' Light gray to gray dense limestone with zones of light brown, fine crystalline limestone.

200' Light gray to gray silty limestone.

180' Cream to off white, very fine to finely crystalline dolomite with some silty zones. This unit contained a 90 feet sandy zone.

5520' Light gray limestone which contained three sandy zones ranging from 40 to 520 feet thick.

1480' Gray, soft to firm shale with zones of interbedded limestone and dolomite.

50' Brown and tan limestone.

330' Gray shale with some interbedded limestone.

90' Light gray dolomite.

200' Gray shale. This unit had near its bottom a five foot orthoquartzite zone.

30' Light gray and tan limestone.

130' Dark gray shale.

17' Gray shale with some hard red siliceous shale at its bottom.

Below this point, 19,527 feet, basement was drilled.

Two cores were taken within the Rome; Core No. 1 at 16,201 feet to 16,260 feet and Core No. 2 at 17,906 feet to 17,915 feet. Both cores were sent to the West Virginia University Geological Department for analysis.

The report summary for Core No. 1 states that the core is probably Upper Lower to Middle Cambrian in age. This was based upon trilobite identification.

The report describes the core as consisting of 1 to 4 inch beds of argillaceous finely crystalline dolomite, finely crystalline dolomite to calcitic finely crystalline dolomite, dolomitic calcilutite, and calcarenite and calcirudite which occur in cycles. These were interbedded with algal mats and stromatolites suggesting a tidal flat depositional environment with the coarser grained limestones representing intra and inter-algal tidal channels. It furthers states that the organic content was sufficient to produce commerical quantities of hydrocarbons, but that reservoir conditions did not exist.

Core No. 2 was composed of dark gray shale. Due to the release of the confining overburden pressure, upon being pulled to surface, this core separated with audible popping sounds into waffers approximately 1/4 to 1/2 inch thick. Due to the core's physical condition, only a preliminary faunal analysis was made. Trilobite fragments indicate the

same age range as Core No. 1.

Within the Rome formation, seventeen (17) gas shows were encountered. These ranged from barely detectable on the hydrocarbon monitor to the show at 13,057 feet which completely saturated monitoring equipment and brought drilling activities to a halt. This show will be discussed in greater detail in this paper.

Gas samples were collected from two shows and analyzed by Chromatograph at Columbia's Kenova Extraction Plant. A sample taken at 11,992 feet tested as 85% methane with a BTU value of 904. The second sample, taken at 11,992 feet tested as 88% methane and 911 BTU's. Both tests gave indications of having air contamination.

No Basal Sand was present.

Basement was encountered at 19,527 feet. A six foot core was cut from 19,521 to 19,537 feet. This core was described by M. T. Heald of the West Virginia University Geology Department as a highly feldspathic gneiss with a composition similar to a granodiorite.

Samples of this core were sent to Dr. John A. S. Adams, Rice University, and Dr. Edward Likiak, University of Pittsburgh, for age determinations. Reported ages were 939 ± 34 million years and 908 ± 18 million years respectively.

Prior to commencement of drilling, an effort was made to determine the presence of abnormal pressure within the prospect area. Bendix United Geophysical Corporation, in conjunction with Bariod Division, prepared a report for Columbia entitled Circulating System Program Including Seismic Pressure Profile in which an effort was made to predict abnormal pressures.

The results of the survey, as summarized in the seismic pressure plot diagram, (see Fig. 8). indicated two zones of abnormal pressure.

The upper interval was from 10,900 to 11,300 feet. This includes the uppermost shale zones within the Rome. Cuttings from these units were tested and classed as hard, brittle illites. These zones gave no indication of being pressured.

The second pressured zone was indicated as being from 16,900 to 19,600 feet. This zone was composed of some carbonates with the bulk being a hard calcareous shale.

A plot of the Calibrated Velocity Log was done in February, 1973, by Birdwell Division, Seismograph Service Corporation. This plot indicated a departure from the normal pressure gradient at approximately 10,800 feet. It also indicates three zones that may represent abnormal pressures: 10,500 to 12,700 feet; 14,250 to 15,000 feet; and 16,500 to 19,537 feet.

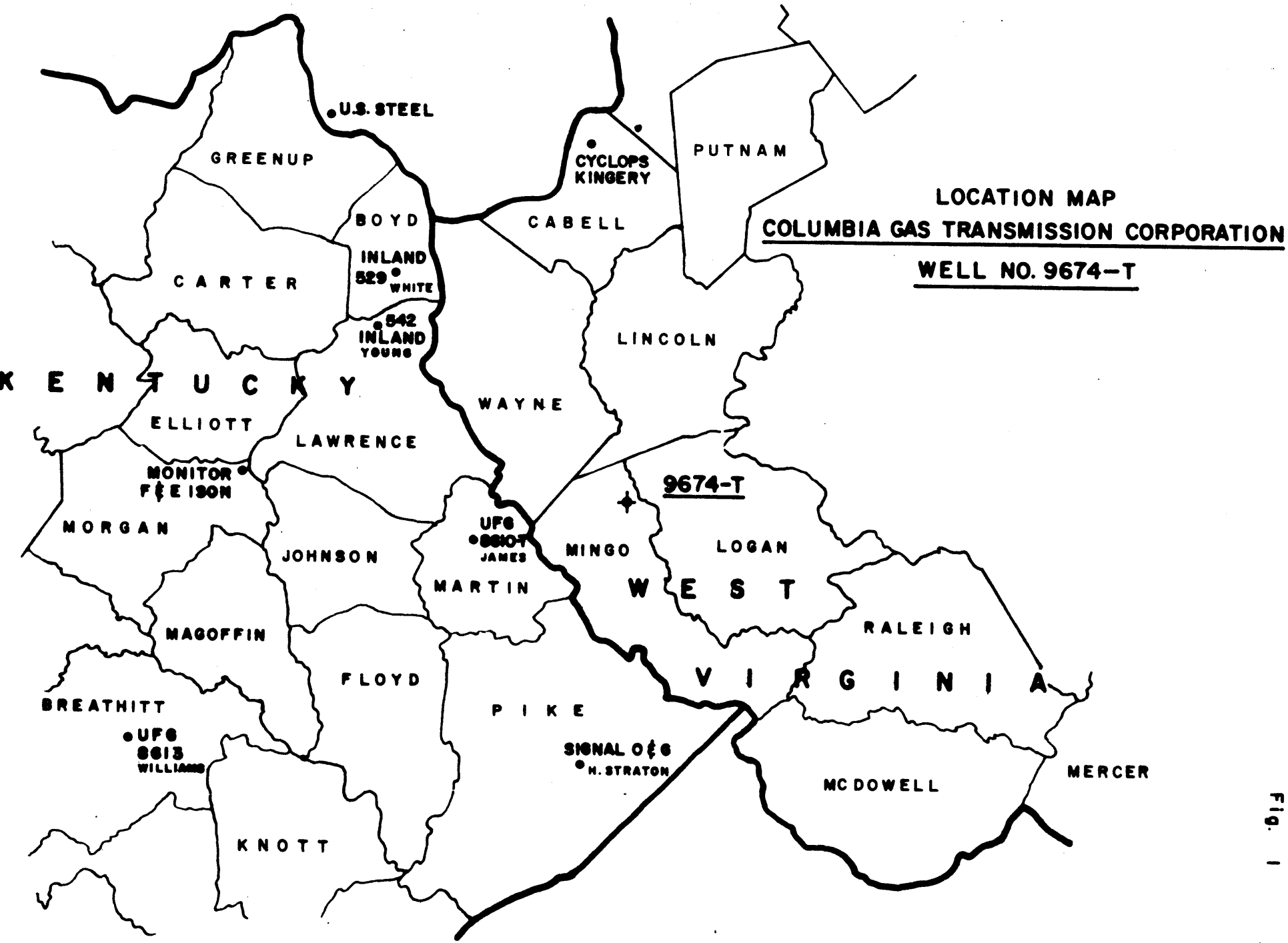
The upper zone, 10,500 to 12,700 feet, is an area of shales and carbonates with porous sandy zones. This zone indicated pressure on a "d" exponent plot, but this may be due to improved drilling practices.

The second zone, 14,250 to 15,000 feet is one of limestone with a sandy zone at the top. No porosity greater than 2% is indicated within this zone by electric logs.

The third zone, 16,550 to 19,537 feet, is composed of interbedded shales, limestones and dolomites.

Abnormal pressure was encountered in a show at 13,057 feet. At this point it became necessary to weigh and maintain drilling mud at 18.1 lbs./gal. This is an equivalent pressure gradient of 0.94 as compared to a normal gradient of 0.465. These gradients are equivalent to 12,290 psi and 6,071 psi respectfully.

The well was drilled to a total corrected depth of 19,537 feet. Evaluation of all data obtained during the drilling indicated that no economical gas or oil reservoirs of Cambro-Ordovician age were present at this location. Even though the well was plugged and abandoned, it made two major contributions to subsequent exploration efforts: a major increase in knowledge of Rome stratigraphy and the presence of abnormally high geopressures within the Appalachian Basin.



LOCATION MAP
COLUMBIA GAS TRANSMISSION CORPORATION
WELL NO. 9674-T

Fig. 1

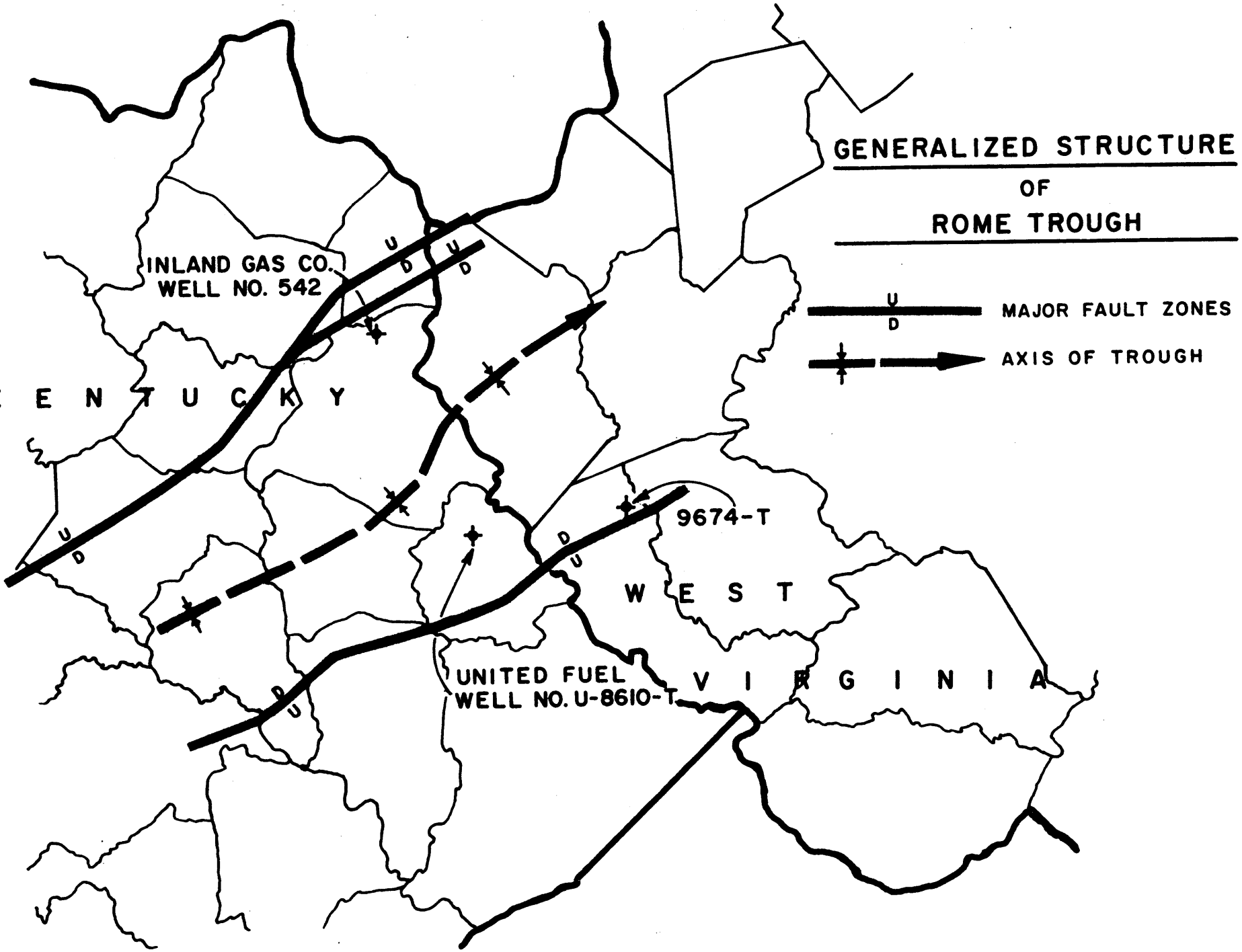

GENERALIZED STRUCTURE
OF
ROME TROUGH
U
D
MAJOR FAULT ZONES
AXIS OF TROUGH
INLAND GAS CO.
WELL NO. 542
E N T U C K Y
9674-T
W E S T
V I R G I N I A
UNITED FUEL
WELL NO. U-8610-T

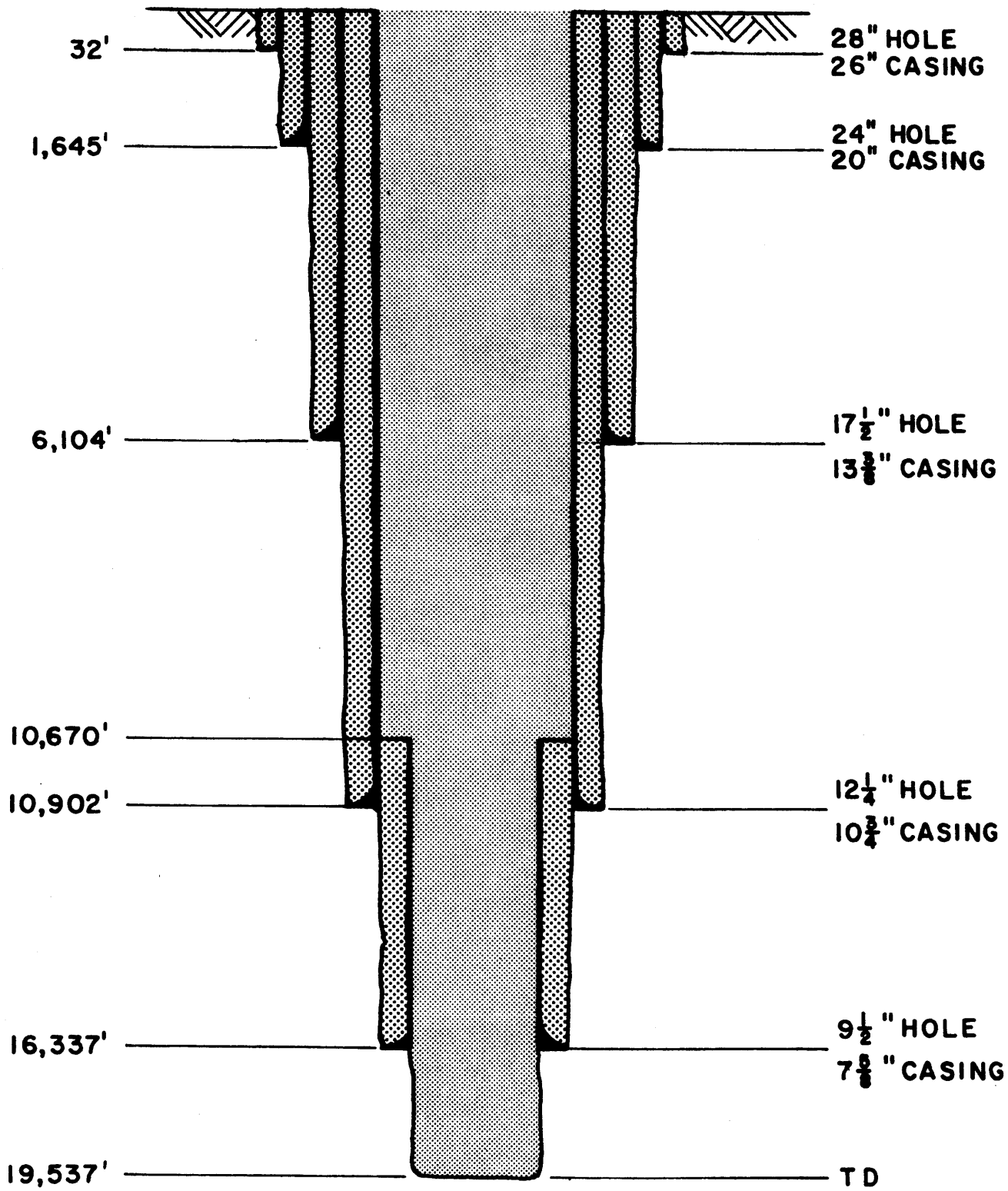
Fig. 2

RIG SPECIFICATIONS

LOFFLAND BROTHERS RIG 111

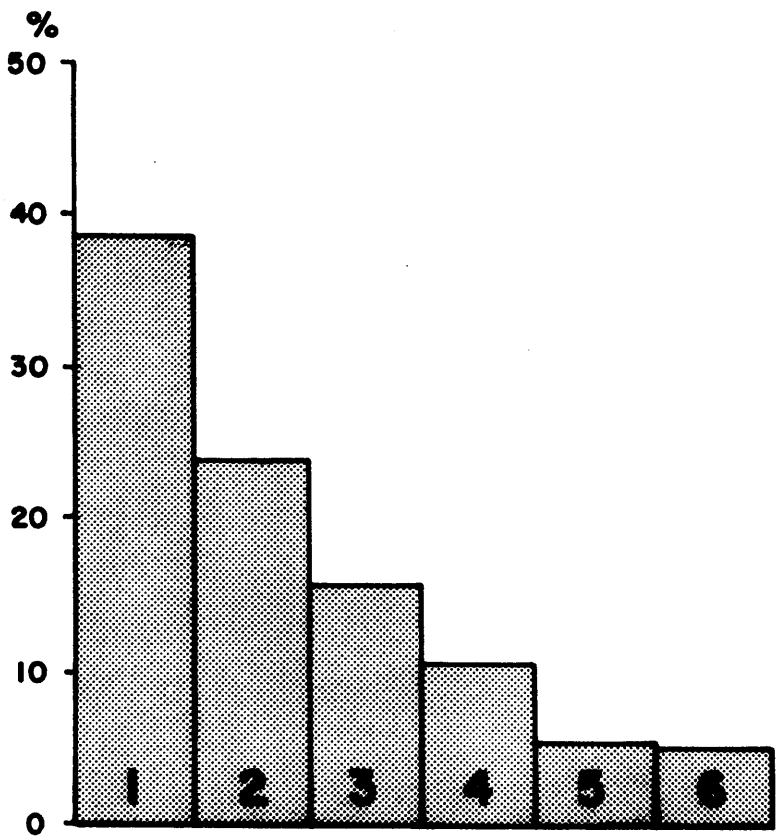
Rated Depth Capacity	20,000'
Derrick:	Continental Emsco RF 142' - 1,300,000# Gross Nominal Capacity
Substructure:	Continental Emsco 23' - 1,600,000# Gross Nominal Capacity
Drawworks:	Continental Emsco A 1500
Auxiliary Brake:	Elmago 6032 Electric Brake
Compound:	Continental Emsco A-75 3 Engine with Dual Pump Drive
Engines:	3 - Waukesha L5790 DU 1002 Int. HP @ 1200 RMP 766 Cont. HP @ 1200 RPM
Mud Pumps:	Continental Emsco F 1300 Triplex - Continental Emsco D 1000
Desander:	Thompson Model 3 L8 - 3 Cone
Mud Tanks:	4 - 8' W x 32' L x 6.5' H
Water Storage:	2 - 8' W x 30' L x 6.5' H
Generators:	170 KW AC - 150 KW AC
Rotary Table:	Continental Emsco 27.5
Traveling Block:	1-3/8" - 6 Sheave - 500 Ton
Crown Block:	Continental Emsco - 7 Sheave
Hook:	BJ 5500 Hydraplex
Swivel:	Continental Emsco 650

Fig. 4



CASING POINTS

COLUMBIA GAS TRANSMISSION CORPORATION
WELL NO. 9674-T
MINGO COUNTY, WEST VIRGINIA



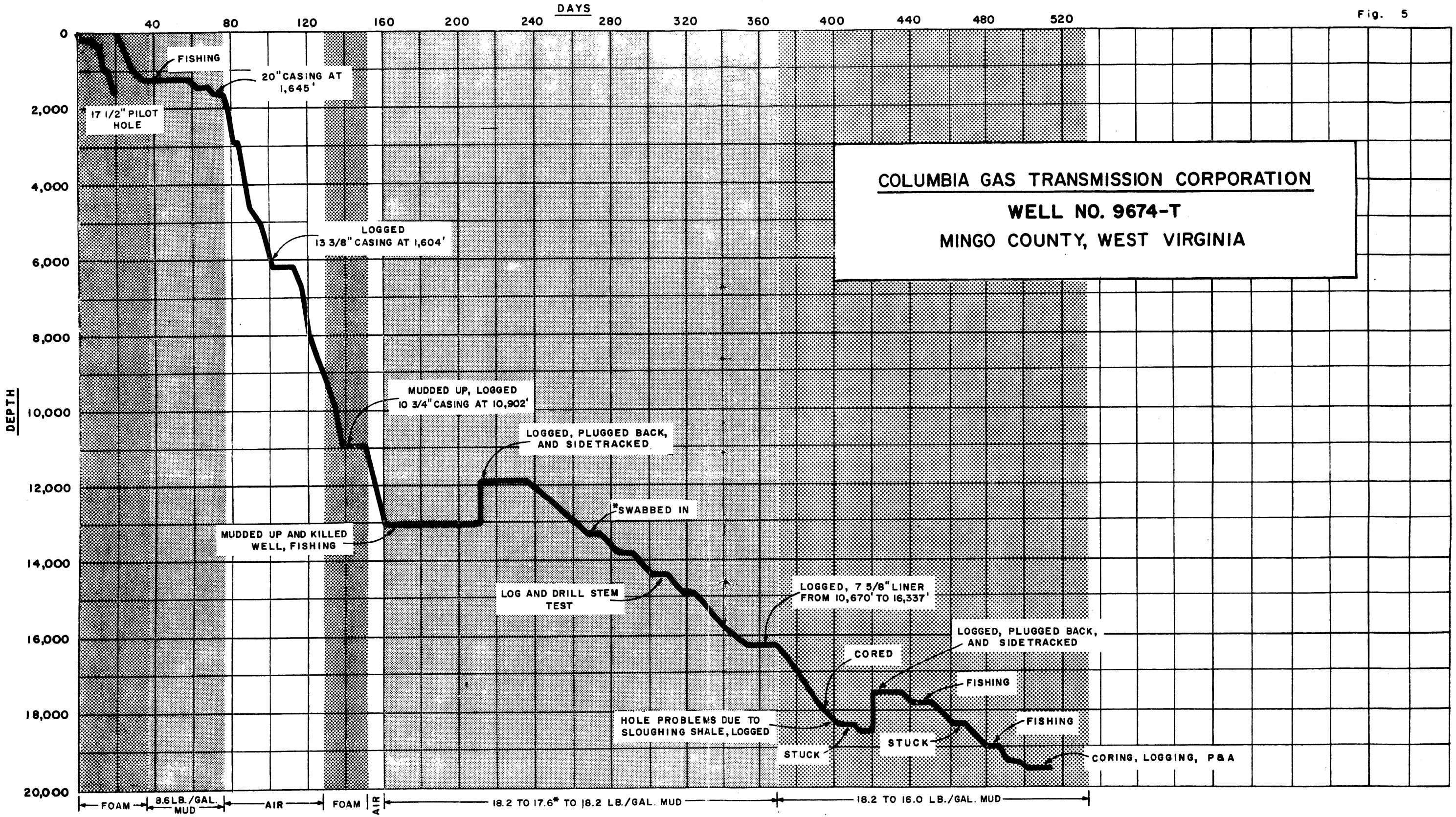
	HOURS	DAYS	%
1) DRILLING AND REAMING	4,771.75	198.8	38.7
2) TRIPS	2,926.25	121.9	23.7
3) FISHING, MUDDING UP, WELL CONTROL	1,918.25	79.9	15.5
4) RIG REPAIRS AND MISCELLANEOUS	1,320.75	55.0	10.7
5) CEMENTING, RUNNING CASING, NIPPLING UP	719.00	30.0	5.8
6) HOLE EVALUATION (LOGGING, CORING, DST)	686.00	28.6	5.6
TOTAL	12,342.00	514.2	100.0

Fig. 5

COLUMBIA GAS TRANSMISSION CORPORATION

WELL NO. 9674-T

MINGO COUNTY, WEST VIRGINIA



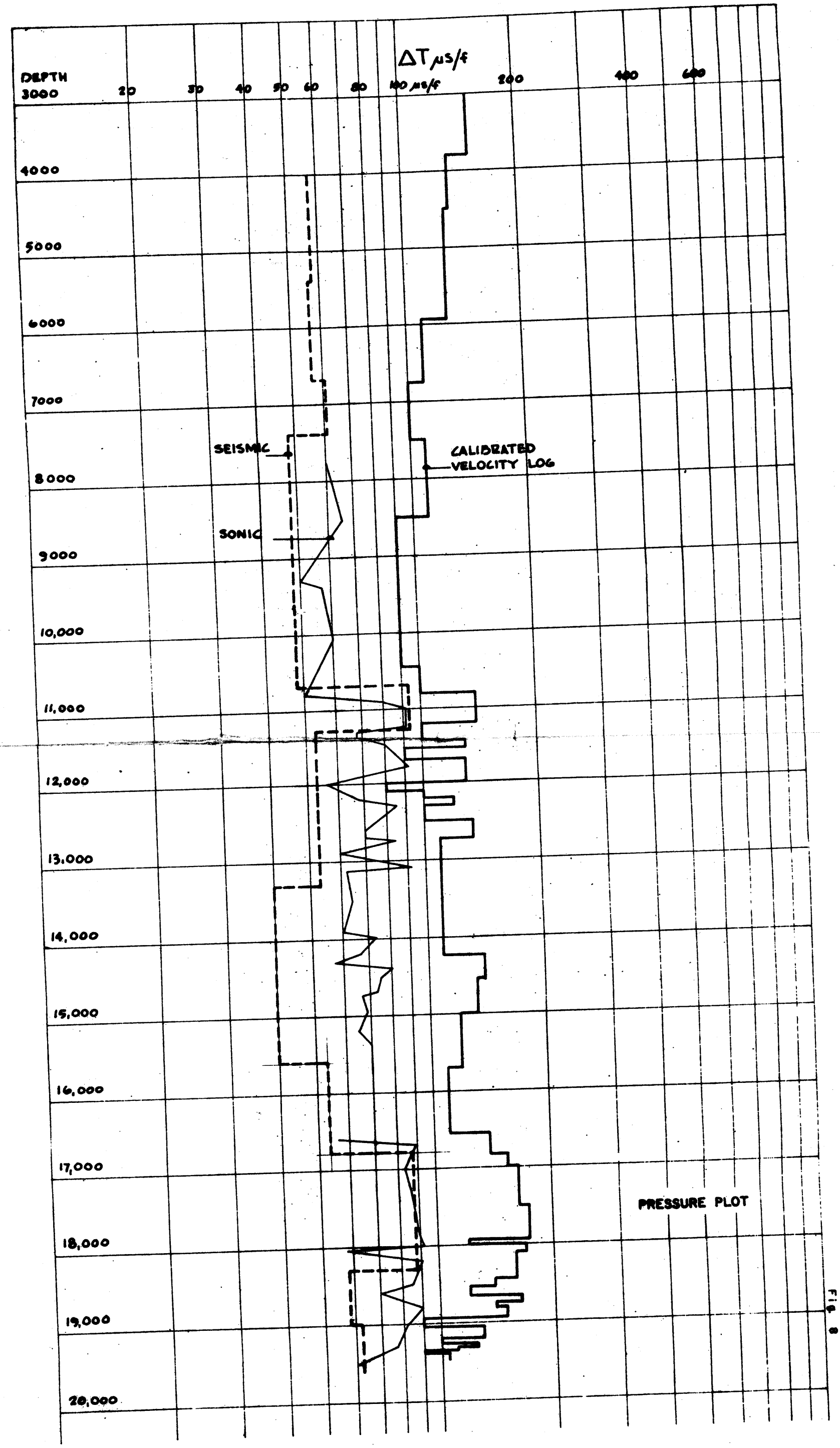

DEPTH
3000
20
30
40
50
60
80
100 μs/f
ΔT μs/f
200
400
600
4000
5000
6000
7000
8000
9000
10,000
11,000
12,000
13,000
14,000
15,000
16,000
17,000
18,000
19,000
20,000
SEISMIC
SONIC
CALIBRATED
VELOCITY LOG
PRESSURE PLOT

Fig 8