UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary Report on an Exploratory Drill Hole--
New Madrid Test Well-1-X in Southeast Missouri

by

Anthony J. Crone and David P. Russ

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PRELIMINARY REPORT ON AN EXPLORATORY DRILL HOLE--
NEW MADRID TEST WELL-1-X IN SOUTHEAST MISSOURI

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INTRODUCTION

As part of the U.S. Geological Survey's investigation of earthquake hazards in the upper Mississippi embayment, a test well (NMTW-1-X) was drilled in the "bootheel" of Missouri, 21 km south-southwest of the town of New Madrid. The primary purpose of the well was to obtain in situ stress measurements from zones within subsurface Paleozoic rocks using the hydraulic fracturing (hydrofracture) technique. Such measurements determine the character and magnitude of the active tectonic stress field in an area and are helpful in evaluating the potential for faulting (Zoback and others, 1978). The new data about the active tectonic stress field can then be used to evaluate the various theories that have been proposed to explain the genesis and characteristics of the upper Mississippi embayment earthquakes.

A second goal of the test well was to extensively study the post-Paleozoic stratigraphy in the area. Detailed stratigraphic information would provide a better understanding of the structural framework of the upper Mississippi embayment. Accurate knowledge of the stratigraphy would also help to identify the reflecting horizons that were recorded in a series of seismic reflection profiles that the U.S. Geological Survey had previously run throughout the upper Mississippi embayment. To strengthen the correlation between reflecting horizons and stratigraphic units, one of the reflection profiles was run within 10 m of the well.

The stratigraphy and structure of the New Madrid, Mo., area are, at present, poorly understood. Only a handful of deep wells and test holes, some with only generalized driller's logs and few with accompanying geophysical logs, are available to aid in interpreting the subsurface geology of the upper Mississippi embayment. Extensive paleontologic and palynologic studies are planned to assist in identifying formal stratigraphic units and to help define the depositional history of the sediments. For the Tertiary and Cretaceous sequences, these investigations will also yield valuable biostratigraphic data by defining the biofacies changes that occur between the well-studied marine facies in the southern part and the time-equivalent, continental and nearshore-deltaic facies in the northern part of the embayment.

This report was prepared to release preliminary data obtained during the drilling phase of the test well. It includes a short text describing mechanical operations and history of the drilling, some initial stratigraphic interpretations of the test-well data, and a brief discussion of studies generated by the project which are now in progress. Attached appendices contain a field driller's log and geophysical logs. In order to maintain consistency with standard drilling usage, measurements related to drilling operations are cited in English units.

TEST WELL LOCATION

The New Madrid Test Well is located in the Point Pleasant, Mo., 7 1/2-minute topographic quadrangle along Missouri State Highway 162, about 1.37 km west of the small town of Linda, Mo. (SW 1/4, SW 1/4, SE 1/4, sec. 32, T. 21 N., R 14 E.)(fig. 1). The site is on the property of Mr. Edward Russell and lies 98.4 m, N. 40° W. of the USGS benchmark plotted on the topographic quadrangle. Elevation of the test well is 86.5 m above mean sea level. This particular location was selected for four reasons: (1) it lies adjacent to a linear zone of numerous recent earthquake epicenters; (2) focal-plane mechanisms, derived from data gathered by a U.S. Geological Survey seismic array deployed in the spring of 1978 (Jordan and others, 1978), suggest that faults in this area have a significant component of normal movement; and interpretation of hydrofracture data is somewhat simplified in a stress field where the maximum compressive stress is vertical (M. D. Zoback, oral commun., 1978); (3) the site lies along one of the seismic reflection profiling lines; and (4) subsurface geologic control is very poor in the area.

MECHANICAL OPERATIONS

Site preparation for the New Madrid Test Well included grading and leveling the drill site, pouring a small concrete slab around the drill hole, and excavating several mud pits 2 m deep. The concrete slab provided a stable, solid foundation upon which the hydraulic jacks of the drill rig could be anchored.

The walls of the mud pits provided excellent cross-sectional exposures of the upper part of the clayey top stratum of the Mississippi River alluvium and revealed several earthquake-induced sandblow dikes (fig. 2). The Mississippi River top-stratum deposits are predominantly dusky, yellow-brown to gray clay that is slightly silty, is locally mottled, and contains dispersed sand grains. The clay is intruded by several bifurcating sand dikes in the form of pipes, lenses, and stringers of grayish- to light-brown, medium- to coarse-grained, quartzose sand containing minor amounts of very coarse sand and fine gravel. The sandblow dikes are evidence that major seismic events have produced periods of intense ground motion (Russ and others, 1978) at the New Madrid Test Well site.

The New Madrid Test Well was drilled by a truck-mounted rotary rig. Most of the well was drilled using rotary tri-cone toothed bits, but parts of the hard Paleozoic rocks were drilled by percussion air hammer bits and rotary tri-cone button bits. Cores were cut by diamond-studded core bits and were recovered in a 30-ft-long Christensen core barrel equipped with a nonrotating inner barrel.

Bentonitic drilling mud was used to stabilize the walls of the hole and to control water flowing from several artesian aquifers. The viscosity and pH of the mud were carefully regulated to reduce excessive fluid loss into highly permeable formations and to maximize the thickness and strength of the borehole-wall mudcake.

Paleozoic rocks encountered in the New Madrid Test Well were initially drilled using air as the drilling fluid. However, as the well was deepened, artesian water flowing from these rocks gradually increased and exceeded the ability of the compressors to lift the fluid out of the hole. Eventually, further drilling with air became impossible. From that point on, produced formation waters were recirculated and used as the drilling fluid.

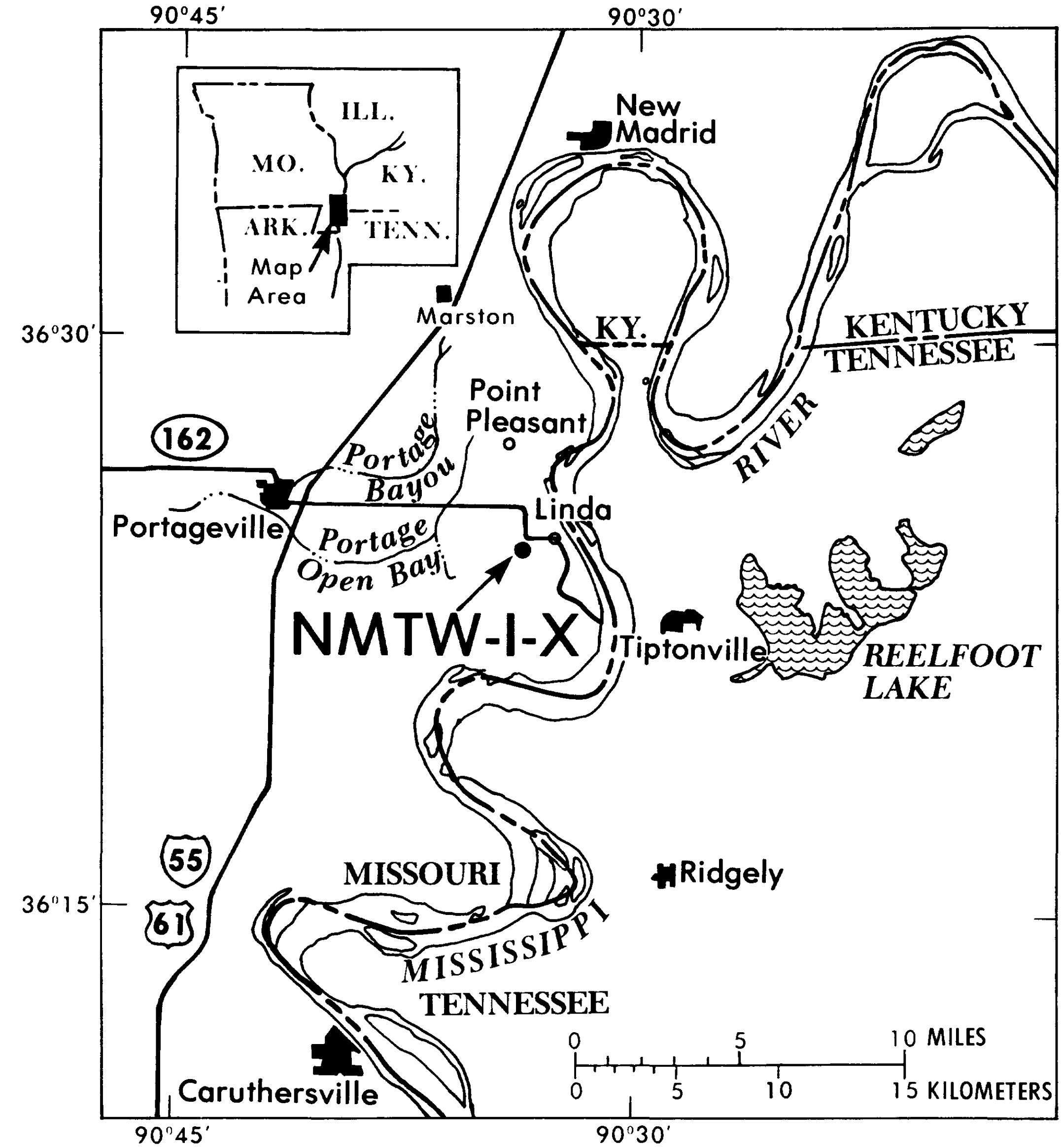

Figure 1.--Location map of New Madrid Test Well NMTW-1-X

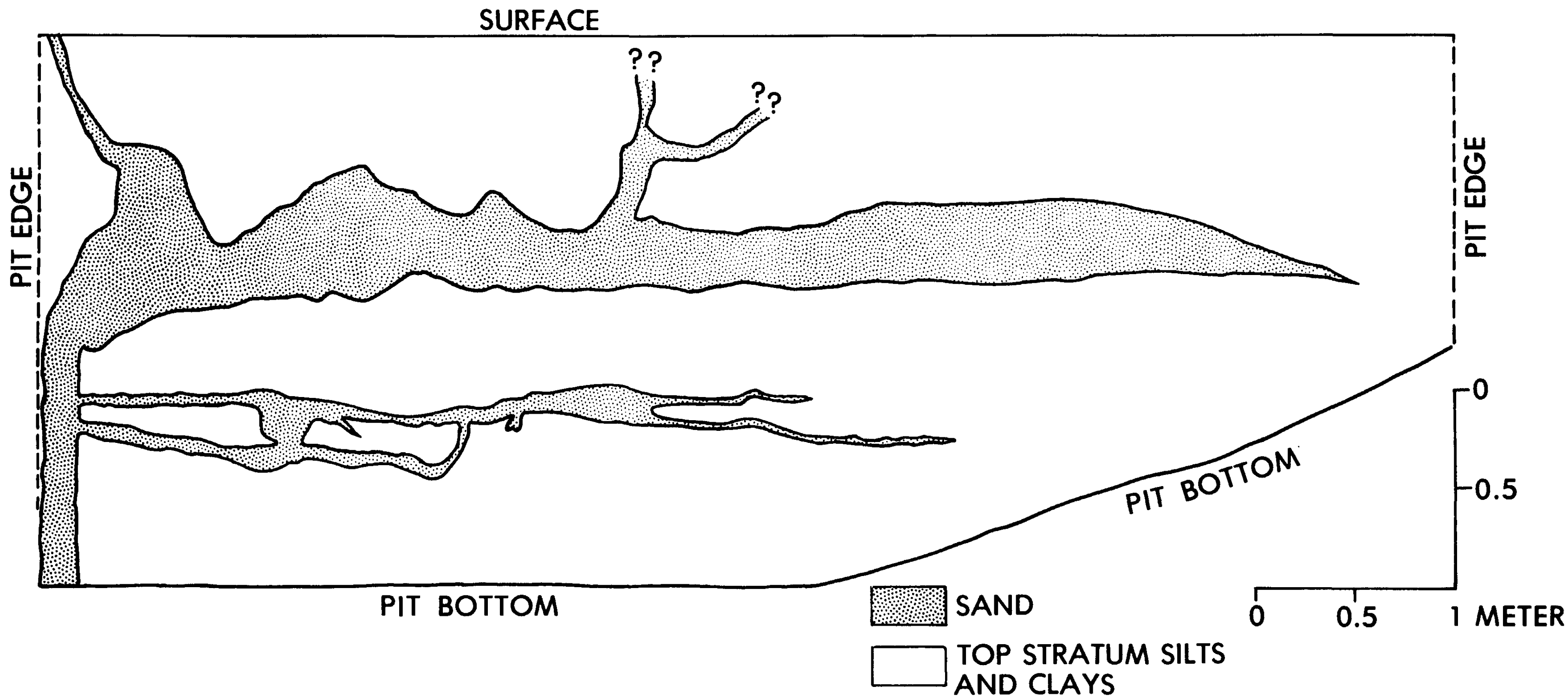

Figure 2.--Sketch map of mud-pit wall showing sandblow dike

Extensive coring and detailed sampling programs in the New Madrid Test Well were designed to maximize the amount of stratigraphic information obtained from the well. Samples of cuttings, compensated for lag time, were collected at 5-ft intervals. Silty and clayey formations were preferentially cored to provide the best samples possible for palynologic and paleontologic analyses. Initially, 850 ft of coring was scheduled, but the coring program was modified according to the ability to recover core and the total available drilling time.

BRIEF HISTORY OF THE NEW MADRID TEST WELL-1-X (NMTW-1-X)

The New Madrid Test Well-1-X, spud on September 26, 1978, was drilled into the top of the Jackson Formation to a depth of 142 ft using a 14 3/4-in. bit. A string of 12 1/2-in. surface casing was set to 140 ft and cemented to the surface.

A coring program was scheduled below the surface casing in the Jackson Formation, but repeated attempts failed to recover any core. Drilling in these poorly indurated silts and clays began again at 166 ft and continued to the top of the Porters Creek Clay at 1,388 ft. At this depth, mud was circulated through the hole for one hour and preparations were made to log the well.

Schlumberger Well Services Company performed the logging operations and attempted to recover a series of sidewall cores. The log suite included a compensated neutron-formation density log, a dual induction-laterolog, and a borehole-compensated sonic survey. Forty-eight sidewall cores were scheduled to be collected, but during the first run with the coring gun, 16 of the 24 coring cups broke their retaining cables and were lost in the hole. The eight remaining core cups were recovered, but the possibility of losing additional core cups forced the cancellation of a second coring run. After the logging was completed, the well was reamed and deepened to 1,400 ft. An intermediate string of 9 5/8-in. casing was set and cemented to total depth (hereinafter referred to as TD). Below the casing, continuous coring in the Porters Creek Clay and the underlying Clayton Formation yielded nearly 100 percent recovery through most of the section. Core recoveries in the underlying McNairy Sand were generally poor, apparently due to the unconsolidated nature of the sediments.

The contact between the soft McNairy Sand and the hard Paleozoic dolomite occurred at a depth of 2,023 ft. The contact was recognized by an abrupt decrease in the drill penetration rate, by the presence of dolomite chips in the well cuttings, and, later, by characteristic deflections on the geophysical logs. Core recovery in the fractured Paleozoic rocks was very poor. Eventually, the coring program was abandoned and the well was deepened by drilling with a percussion airhammer and rotary tri-cone bits. The hole was drilled and reamed to 2,060 ft, and a string of 6 5/8-in. casing was set and cemented to TD.

Almost immediately after drilling below the 6 5/8-in. casing, artesian water from the Paleozoic rocks began to flow at the rate of 4 to 6 gal/min at the surface. The flow gradually increased to about 30 gal/min as the well was deepened. At 2,302 ft, the well intersected an 8-ft-thick fracture zone and the artesian flow increased rapidly to more than 500 gal/min.

Caving of the fractured zone and the high volume of water originating from it immediately caused operational problems. The drill bit became stuck at 2,316 ft when debris from the fractured zone washed in around the drill string while another length of pipe was being added to the string. Eventually, the driller managed to dislodge the bit and recovered all of the drill pipe from the hole. An attempt to seal the fractured zone with cement failed. The possibility of more caving made additional drilling hazardous and finally led to the decision to terminate drilling. The hydrofracture stress tests had to be conducted in the Paleozoic rocks already penetrated by the well.

PRELIMINARY RESULTS AND CONTINUING STUDIES OF NEW MADRID TEST WELL-1-X

The general stratigraphic section penetrated in the New Madrid Test Well-1-X and the tentative formation tops are listed in table 1. These interpretations were made from the driller's log (appendix 1) and the geophysical logs (appendix 2).

A preliminary examination of the data suggests that some revisions in the stratigraphic nomenclature for parts of the Tertiary section in southeastern Missouri and the upper Mississippi embayment are warranted: (1) the Claiborne Group is tentatively identified for the first time in the subsurface in southeastern Missouri, and (2) the Wilcox Group is divided into three distinct formations. Detailed sample studies and core analyses are currently in progress to help define lithologic variations and to refine paleontologic and palynologic boundaries.

The artesian water from the Paleozoic dolomites is generally of good quality for most uses (analyses performed by the Missouri Division of Geology and Land Survey), but relatively high concentrations of sodium, chloride, and total dissolved solids reduce its value for human consumption (Mark Marikos, oral commun., 1978). The artesian pressure measured at the surface is approximately 40 psi, generating a hydrostatic head of 92 ft and producing a calculated open flow of 500-600 gal/min. Results of the preliminary chemical analyses are shown in table 2. Additional analyses for heavy metals and studies to determine the source of the water are in progress.

Table 1.--Preliminary stratigraphic section in NMTW-1-X

[Subject to future revisions and reinterpretation]

<table>
<tr><th>Age</th><th>Total depth (ft)</th><th>Unit thickness (ft)</th><th colspan="2">Unit or formation</th><th>General lithologic description</th></tr>
<tr><td>Quaternary</td><td>0-135 ±</td><td>135 ±</td><td colspan="2">Mississippi Valley alluvium</td><td>20 ft of clay and silty clay overlying sand and gravel. Gravel occurs in lower 15 ft (?).</td></tr>
<tr><td rowspan="7">Eocene
—?—</td><td>135-270 (?)</td><td>135 (?)</td><td colspan="2">Jackson Formation</td><td>Sand with interbedded gray silt and clay.</td></tr>
<tr><td rowspan="3">270 (?)-1048</td><td rowspan="3">778 (?)</td><td rowspan="3">Claiborne Group</td><td>Cockfield (?) Formation</td><td>Clay in upper 10 ft. Silt and sandy silt, some sand, some lignite.</td></tr>
<tr><td>Cook Mountain (?) Formation</td><td>Gray to gray-green silty clay and silty sandy clay; some lignite.</td></tr>
<tr><td>Memphis Sand</td><td>Sand, lignite, minor interbeds of clay.</td></tr>
<tr><td rowspan="3">1048-1377 (?)</td><td rowspan="3">329 (?)</td><td rowspan="3">Wilcox Group</td><td>Flour Island Formation</td><td>Clay and silty clay with interbeds of sand and silt.</td></tr>
<tr><td>Fort Pillow Sand</td><td>Sand, medium to coarse; glauconite.</td></tr>
<tr><td>Old Breastworks Formation</td><td>Clay, sandy and silty; noncalcareous.</td></tr>
<tr><td rowspan="2">Paleocene</td><td rowspan="2">1377 (?)-1703 (?)</td><td rowspan="2">326 (?)</td><td rowspan="2">Midway Group</td><td>Porters Creek Clay</td><td>Clay, generally calcareous; silty and glauconitic at base.</td></tr>
<tr><td>Clayton Formation</td><td>Limestone, glauconitic, fossiliferous; some clay.</td></tr>
<tr><td rowspan="2">Cretaceous</td><td>1703 (?)-1706 (?)</td><td>3 (?)</td><td colspan="2">Owl Creek Formation</td><td>Clay.</td></tr>
<tr><td>1706 (?)-2023</td><td>317 (?)</td><td colspan="2">McNairy Sand</td><td>Sand, quartzose, fine to coarse grained; interbedded with clay, dk. gray to black.</td></tr>
<tr><td>Paleo-zoic</td><td>2023-2316 +</td><td>293 +</td><td colspan="2">Paleozoic dolomite</td><td>Dolomite, dk. gray to white, fine to to coarse crystalline, contains pyrite.</td></tr>
</table>

Table 2.--Quality of water from Paleozoic dolomite

[Data from Mark Marikos, geologist, Missouri Division of Geology and Land Survey]

	Parts per million
Calcium (Ca)	108
Magnesium (Mg)	30
Sodium (Na)	310
Potassium (K)	12
Total Manganese (Mn)	.02
Total Iron (Fe)	.64
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	146.6
Sulfate (SO_4)	83
Chloride (Cl)	650
Fluoride (F)	1.4
Total dissolved solids	1,559
Total hardness	345.8
Carbonate (CO_3) hardness	121.9
Noncarbonate hardness	223.9

The major objective of drilling the New Madrid Test Well-1-X was to conduct hydrofracture stress measurements in conjunction with earthquake hazard studies; however, attempts to fracture the Paleozoic bedrock were generally unsuccessful. Extensive natural fractures and vuggy porosity in the dolomite made it impossible to generate the confining pressures necessary to create artificial fractures and thereby measure the inherent stress directions in three different tests. In a partially successful fourth test, a preexisting fracture was opened with an orientation of N. 43° E. and a dip of about 80° to the northwest. The results of this stress test imply that earthquakes in the vicinity of the New Madrid Test Well cannot be due to purely normal faulting (M. D. Zoback, oral commun., 1979), an observation that is consistent with earthquake focal mechanism solutions obtained from a nearby USGS microearthquake survey (Jordan and others, 1978). Tentative future plans are currently being made to deepen the test well so that more reliable hydrofracture stress measurements can be obtained in areas of suitable rock.

Lithologic, paleontologic, and palynologic analyses of cores and cuttings from the New Madrid Test Well-1-X are currently in progress. When completed, the results from these studies and data from the geophysical logs (appendix 2) will be combined and then correlated with similar data from surrounding wells. The faunal and pollen studies will help in the identification of formal stratigraphic units and will refine stratigraphic boundaries within Tertiary and Cretaceous strata. The lithologic studies and geophysical logs will aid in interpreting the structural evolution of the upper Mississippi embayment.

The subsurface information obtained from the well will also be useful in identifying the major reflective horizons that were observed in seismic-reflection profiles run in the area. In order to accurately correlate between the well and the reflection profiles, the logs from the New Madrid Test Well-1-X were computer-processed to produce a synthetic seismogram (fig. 3). The major reflective horizons predicted from the computer model can be directly correlated with the reflections observed in the seismic-reflection profiles.

NEW MADRID TEST WELL 1-X

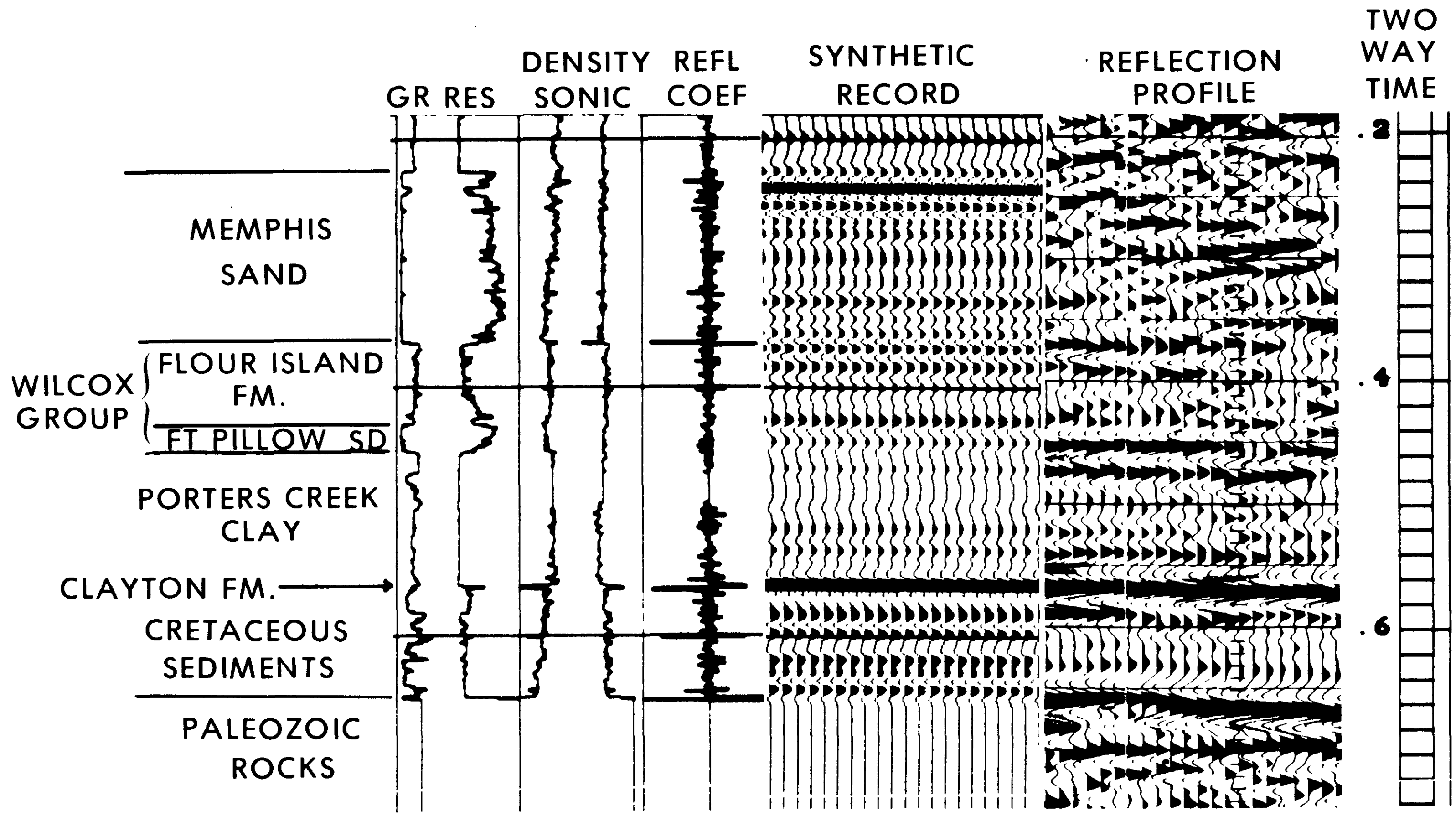

Figure 3.--Correlation of synthetic seismogram with part of nearby reflection profile and selected stratigraphic units. GR: gamma ray log; RES: resistivity log; REFL COEF: reflection coefficient

REFERENCES CITED

Jordan, Dan, O'Connell, Don, Cookley, John, Zoback, Mark, and Bufe, Chuck, 1978, Microearthquakes near Reelfoot Lake, Tennessee: American Geophysical Union, 4th Annual Midwest Meeting, Program with Abstracts, St. Louis, Mo., p. 11.

Russ, D. P., Stearns, R. G., and Herd, D. G., 1978, Map of exploratory trench across Reelfoot scarp, northwestern Tennessee: U.S. Geological Survey Miscellaneous Field Studies Map MF-985.

Zoback, M. D., Healy, J. H., Roller, J. C., Gohn, G. S., and Higgins, B. B., 1978, Normal faulting and in situ stress in the South Carolina coastal plain near Charleston: Geology, v. 6, no. 3, p. 147-152.

Appendix 1.--Driller's Log and Preliminary Sample Description

Depth (ft)	Description
170-175	First sandy zone encountered in or below the Jackson Fm.
175-220	Occasional zones of sand interbedded with gray silts and clays.
220-290	No description.
290-300	Gray clay with blocky, woody chunks of lignite.
300-330	Gray to gray-brown silt, clayey silt, and sandy silt; becoming sandy.
330-360	Gray to gray-brown sandy silt; occasionally contains lignite.
360-370	As above, becoming brown; increase in clay at 366 ft; drilling slower.
370-380	Sandy silt, very fine.
380-400	Silt and very fine sand, dark chocolate-brown, clayey; contains lignite/peat.
400-430	As above.
430-470	Silty clay, light-gray, sandy; contains bits of lignite.
470-540	Silty clay; light-gray and occasionally bluish-green; minor lignite; sandy.
540-590	Silty clay, gray; minor sand; no lignite. Penetration rate increases and bit bounces slightly at 589 ft.
590-600	Sand, medium to coarse, quartzose; trace feldspar; trace chert; trace lignite.
600-630	Sand, coarse to very coarse; grading to fine gravel; quartzose; increase in amount of rock fragments; trace of lignite. Driller reports water flowing from drill pipe during connection at 602 ft.
630-640	Sand, as above, and clay, dark-gray; slightly silty.
640-650	Sand, as above, and clay, gray to greenish-gray, silty, lignitic.
650-840	Sand; ranging in size from very coarse to very fine with medium size predominating; quartzose; occasional iron-stained grains; rock fragments; minor to abundant lignite; occasionally contains pyrite.
840-860	Sand, medium to coarse; grading to fine gravel; quartzose; lignitic; occasionally contains chocolate-brown, silty peat and light-gray silt.
860-940	Sand, predominantly medium-grained to very fine-grained; quartzose; lignitic; trace pyrite; rock fragments.
940-960	Sand, coarse to very coarse, quartzose; lignitic.
960-1050	Sand, medium-grained; ranges from fine-grained to very coarse grained; quartzose; lignitic; pyrite; occasional flakes of light-gray to greenish-gray clay.
1050-1080	Clay, light- to medium-gray, soft; slightly silty; lignitic; trace muscovite.
1080-1210	Silty clay, medium-gray, occasionally dark-gray, sandy; occasionally lignitic.
1210-1230	Silty clay, as above; increasing sand content with medium to coarse-size grains; rock fragments.
1230-1335	Sand, medium-grained to very coarse grained, quartzose.
1335-1390	Silty clay and clayey silt, medium- to dark-gray, sandy, micaceous; trace lignite; locally white and light green.
1390-1670	Clay, dark-gray, silty, hard, micaceous, fossiliferous; breaks with conchoidal fracture; locally contains pyrite; gastropods and foraminifera visible.

Appendix 1.--Driller's log and preliminary sample description--Continued

Depth (ft)	Description
1670-1695	Silt and silty clay, dark-gray and green-gray, calcareous, fossiliferous, micaceous.
1695-1705	Limestone, white to gray-white, highly glauconitic; abundant fossils; iron stained.
1705-1770	Sand, medium to fine, quartzose, argillaceous, unconsolidated.
1770-1780	Clay, dark-gray; contains pyrite concretions.
1780-1880	Sand, medium to fine, quartzose; interbedded with clay, dark-gray, micaceous, calcareous; contains pyrite nodules.
1880-1910	Clay, dark-gray, hard; with minor amounts of medium sand.
1910-2020	Sand, fine to coarse, quartzose; interbedded with clay, dark-gray to black, slightly fissile.
2020-2030	Dolomite, dark-gray, massive, vugular, slightly siliceous, highly fractured; and shale, dark-gray to black.
2030-2045	Dolomite, medium- to dark-gray and white, finely crystalline, argillaceous; and shale, dark-gray to black, soft, silty, noncalcareous.
2045-2060	No description.
2060-2065	Dolomite, medium- to dark-gray, vugular, sandy; some vugs filled with sand.
2065-2080	No description.
2080-2130	Dolomite, medium- to dark-gray, finely crystalline, sandy; contains pyrite; vugs lined with dolomite rhombohedrons.
2130-2315	Dolomite, light-gray to white and dark-gray, fine to coarsely crystalline, hard; pyrite common; decreasing sand content.

Figure 3.--Natural gamma log for drill-hole JMM2

NAT. NUCLEAR LOG

U.S. GEOLOGICAL SURVEY

TYPE: GAMMA DATE: 6-18-79

District or Project: ____

LOCATION: State Colo. County Jackson Town ____

FILE LOCATION NO.: ____

LOGGING INFORMATION

Operator(s) L. SHOAFF
Equipment Address: USGS, Denver
Logger type: ____ No. ____
Tool type: ____
Detector type: Scintillation
Source type: ____
Source size: ____ C; ____ MC
Source spacing: ____
Tool length, cable head to detector 1 ft ____ in
Calibration: See LOG ____ cps
Logging speed: 17 ft/min up down
Log vert. scale: 10 ft/in

MODULE SETTINGS

Scale switch (rate or counts): 50 (cps) chart div (or) ____ API (full scale) (circle as applicable)

T. C. switch: 4 sec.
Position Pot. (Base, zero, or suppression): 10 Dial Div.
Sensitivity Pot. (Span): 7.27 Dial Div.
Discrimination Pot.: 5 Dial Div.
Input pulse: 1.5 volts; Polarity NEG.
Output switch: (normal) reverse
Actual scale: ____ cps chart div (or) ____ API full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:	5.10		
Sensitivity Pot.:	5.00		

Run No. 1 of 1

Remarks: Run through drillstem

WELL INFORMATION

Well No. (USGS): JMM 2
Other: ____
Map or Quad Johnny Moore Mtn. Quad
Site description T. 8 N. R 78 W., Sec. 10 SE 1/4 NE 1/4
Agency or Owner: ____
Address: ____
Altitude of L.S. 8225'
Log M.P. ____ Log TD 341 ft
Btm log interval: ____ ft Well TD: 355' ft
Top log interval: ____ ft
Type of finish: ____
Casing: Elev. of top ____ ft/in Above Below L.S.

I.D. ____, from ____ to ____, type ____
I.D. ____, from ____ to ____, type ____
I.D. ____, from ____ to ____, type ____

Cement: from ____ to ____

Perf. interval(s) from ____ to ____, type ____
Open hole diameter: ____ from ____ to ____
____ from ____ to ____

Fluid level: 910 (ft)/in Above At (Below) (L.S.), Top Csg

Fluid type: Water. temp ____ °F, °C
Fluid resist.: ____ ohm-m
Driller: Steve Roberts
Address: USGS, Denver
Type of rig: ROTARY
Date started: 6-6-79 completed 6-18-79
Aquifer or formation: ____

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well: ____

GPO 843-099

Figure 4.--Gamma-gamma density log for drill-hole JMM2

NUCLEAR LOG

TYPE: GAMMA-GAMMA DENSITY DATE: 6-18-79

LOCATION: State COLO. County Jackson Town

LOGGING INFORMATION

Operator(s) L. SHOAFF

Equipment Address: USGS, Denver Fed. Center

Logger type: No.

Tool type:

Detector type: Scintillation

Source type: Cs 137

Source size: C; 125 MC

Source spacing:

Tool length, cable head to detector 4 ft 6 in

Calibration: see log cps

Logging speed: 17 ft/min up down

Log vert. scale: 10 ft/in

MODULE SETTINGS

Scale switch (rate or counts): 100 (cps) chart div (or) API (full scale) (circle as applicable)

T. C. switch: 4 sec.

Position Pot. (Base, zero, (or suppression)): 8.22 & 9.21 Dial Div.

Sensitivity Pot. (Span): 2.38 & 2.88 Dial Div.

Discrimination Pot.: 5 Dial Div.

Input pulse: 1.5 volts; Polarity Pos.

Output switch: (normal) reverse

Actual scale: cps chart div (or) API full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:	5.08		
Sensitivity Pot.:	5.00		

Run No. 1 of 1

Remarks:

U.S. GEOLOGICAL SURVEY

District or Project:

FILE LOCATION NO.:

WELL INFORMATION

Well No. (USGS): JMM2

Other:

Map or Quad Johnny Moore Mtn.

Site description T. 8 N., R 78 W., Sec. 10 SE 1/4 NE 1/4

Agency or Owner:

Address:

Altitude of L.S. 8225'

Log M.P. Log TD 350 ft

Btm log interval: ft Well TD: 355 ft

Top log interval: ft

Type of finish:

Casing: Elev. of top ft/in Above Below L.S.

I.D. , from to , type

I.D. , from to , type

I.D. , from to , type

Cement: from to

Perf. interval(s) from to , type

Open hole diameter: from to

from to

Fluid level: 41 (ft)/in Above At (Below) (L.S.) Top Csg

Fluid type: Water . temp °F, °C

Fluid resist.: ohm-m

Driller: Steve Roberts

Address: USGS, Denver

Type of rig: Rotary

Date started: 6-6-79 completed 6-18-79

Aquifer or formation:

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well:

GPO 843-099

Figure 5.--Neutron log for drill-hole JMM2

NUCLEAR LOG

U.S. Geological Survey

TYPE: NEUTRON DATE: 6-18-79

LOCATION: State COLO. County Jackson Town ______

District or Project: ______

FILE LOCATION NO.: ______

LOGGING INFORMATION

Operator(s) L. SHOAFF
Equipment Address: USGS, Denver
Logger type: ______ No. ______
Tool type: ______
Detector type: Scintillation
Source type: Am Be 241
Source size: 3 C; ______ MC
Source spacing: ______
Tool length, cable head to detector 7 ft ___ in
Calibration: See Log ______ cps
Logging speed: 17 ft/min up down
Log vert. scale: 10 ft/in

MODULE SETTINGS

Scale switch (rate or counts): 500 (cps) chart div (or) API (full scale) (circle as applicable)

T. C. switch: 4 sec.
Position Pot. (Base, zero, or (suppression)): 9.02 & 9.82 Dial Div.
Sensitivity Pot. (Span): 5.56 & 10 Dial Div.
Discrimination Pot.: 5 Dial Div.
Input pulse: 1.5 volts; Polarity POS.
Output switch: (normal); reverse
Actual scale: ______ cps chart div (or) API full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:	5.09		
Sensitivity Pot.:	5.00		

Run No. 1 of 1

Remarks: ______

WELL INFORMATION

Well No. (USGS): JMM2
Other: ______
Map or Quad Johnny Moore MTN.
Site description T. 8 N., R. 78 W., Sec 10
SE 1/4 NE 1/4
Agency or Owner: ______
Address: ______
Altitude of L.S. 8225'
Log M.P. ______ Log TD 350 ft
Btm log interval: ______ ft
Top log interval: ______ ft
Well TD: 355 ft
Type of finish: ______
Casing: Elev. of top ______ ft/in Above Below L.S.

I.D. ______, from ______ to ______, type ______
I.D. ______, from ______ to ______, type ______
I.D. ______, from ______ to ______, type ______

Cement: from ______ to ______

Perf. interval(s) from ______ to ______, type ______
Open hole diameter: ______ from ______ to ______
______ from ______ to ______

Fluid level: 52 (ft)/in Above At (Below) (L.S.), Top Csg
Fluid type: Water . temp ______ °F, °C
Fluid resist.: ______ ohm-m
Driller: Steve Roberts
Address: USGS, Denver
Type of rig: Rotary
Date started: 6-6-79 completed 6-18-79
Aquifer or formation: ______

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well: ______

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Figure 6.--Natural gamma log for drill-hole GNW1

NUCLEAR LOG

U.S. GEOLOGICAL SURVEY

TYPE: *NAT. GAMMA* DATE: *7-3-79*

District or Project: ______

LOCATION: State *COLO.* County *JACKSON* Town ______

FILE LOCATION NO.: ______

LOGGING INFORMATION

Operator(s) *L. SHOAFF*
Equipment Address: *USGS, Denver*
Logger type: ______ No. ______
Tool type: ______
Detector type: *Scintillation*
Source type: ______
Source size: ______ C; ______ MC
Source spacing: ______
Tool length, cable head to detector *1* ft ______ in
Calibration: *See LOG* cps
Logging speed: *17* ft/min up down
Log vert. scale: *10* ft/in

MODULE SETTINGS

Scale switch (rate or counts): *50* (cps) / API } chart div (or) (full scale)
(circle as applicable)

T. C. switch: *4* sec.
Position Pot. (Base, zero, or (suppression)): *10* Dial Div.
Sensitivity Pot. (Span): *6.96* Dial Div.
Discrimination Pot.: *5* Dial Div.
Input pulse: *1.5* volts; Polarity *NEG.*
Output switch: (normal) reverse
Actual scale: ______ cps / ______ API } chart div (or) full scale
(circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:	*5.19*		
Sensitivity Pot.:	*5.00*		

Run No. *1* of *1*

Remarks: ______

WELL INFORMATION

Well No. (USGS): *GNW-1*
Other: ______
Map or Quad *Gould NW Quad*
Site description *T. 8 N., R. 78 W., Sec 10 SW 1/4 NE 1/4*
Agency or Owner: ______
Address: ______
Altitude of L.S. ______
Log M.P. ______ Log TD *102* ft
Btm log interval: ______ ft
Top log interval: ______ ft Well TD: *115* ft
Type of finish: ______
Casing: Elev. of top ______ ft/in Above / Below L.S.

I.D. ______, from ______ to ______, type ______
I.D. ______, from ______ to ______, type ______
I.D. ______, from ______ to ______, type ______

Cement: from ______ to ______
Perf. interval(s) from ______ to ______, type ______
Open hole diameter: ______ from ______ to ______
______ from ______ to ______

Fluid level: *10* (ft)/in Above / At / (Below) (L.S.), Top Csg
Fluid type: *WATER* . temp ______ °F, °C
Fluid resist.: ______ ohm-m
Driller: *STEVE ROBERTS*
Address: *USGS, Denver*
Type of rig: *ROTARY*
Date started: *7-2-79* completed *7-3-79*
Aquifer or formation: ______

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well: ______

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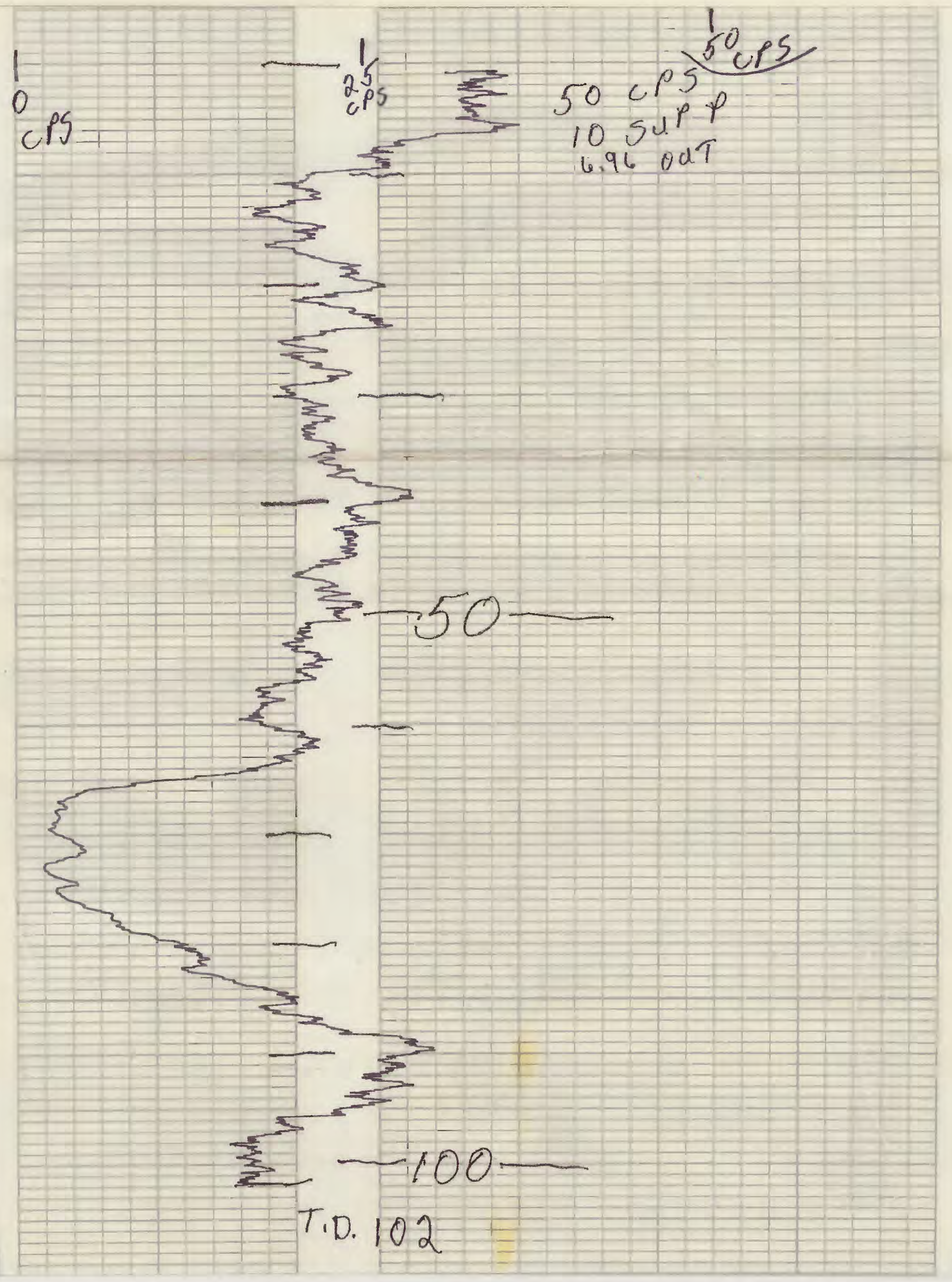

Figure 7.--Gamma-gamma density log for drill-hole GNW1

NUCLEAR LOG

U.S. GEOLOGICAL SURVEY

TYPE: GAMMA-GAMMA DENSITY DATE: 7-3-79

District or Project:

LOCATION: State COLO. County JACKSON Town

FILE LOCATION NO.:

LOGGING INFORMATION

Operator(s): L. SHOAFF
Equipment Address:
Logger type: No.
Tool type:
Detector type: Scintillation
Source type: Cs 137
Source size: C; 125 MC
Source spacing: 10 in.
Tool length, cable head to detector 4 ft 6 in
Calibration: See Log cps
Logging speed: 17 ft/min up down
Log vert. scale: 10 ft/in

MODULE SETTINGS

Scale switch (rate or counts): 100 (cps) chart div (or) API (full scale) (circle as applicable)

T. C. switch: 4 sec.
Position Pot. (Base, zero, or (suppression)): 9.52 Dial Div.
Sensitivity Pot. (Span): 2.58 Dial Div.
Discrimination Pot.: 5 Dial Div.
Input pulse: 1.5 volts; Polarity POS.
Output switch: (normal) reverse
Actual scale: cps chart div (or) API full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:	5.18		
Sensitivity Pot.:	5.00		

Run No. 1 of 1

Remarks:

WELL INFORMATION

Well No. (USGS): GNW-1
Other:
Map or Quad: Gould NW Quad
Site description: T.8N., R.79W., Sec 10 SW1/4 NE1/4
Agency or Owner:
Address:
Altitude of L.S.
Log M.P. Log TD 107 ft
Btm log interval: ft
Top log interval: ft Well TD: 115 ft
Type of finish:
Casing: Elev. of top ft/in Above Below L.S.

I.D. , from to , type
I.D. , from to , type
I.D. , from to , type

Cement: from to

Perf. interval(s) from to , type
Open hole diameter: from to
from to

Fluid level: 9 (ft)/in Above At (L.S.), Top Csg (Below)

Fluid type: WATER . temp °F, °C
Fluid resist.: ohm-m
Driller: STEVE ROBERTS
Address: USGS, DENVER
Type of rig: ROTARY
Date started: 7-3-79 completed 7-3-79
Aquifer or formation:

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well:

GPO 843-099

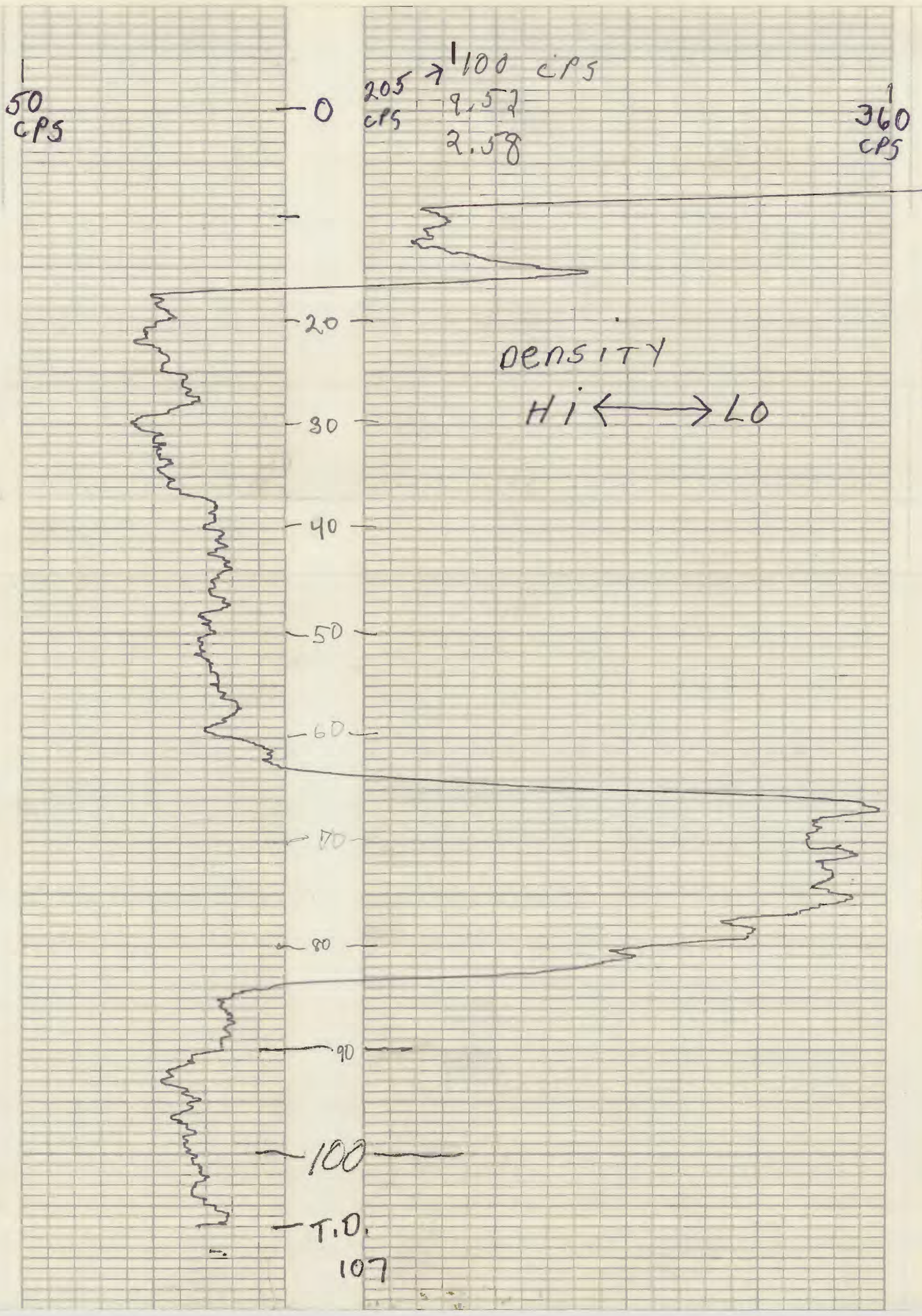

Figure 8.--Neutron log for drill-hole GNW1

NUCLEAR LOG

U.S. GEOLOGICAL SURVEY

TYPE: NEUTRON DATE: 7-3-79

District or Project:

LOCATION: State COLO. County JACKSON Town

FILE LOCATION NO.:

LOGGING INFORMATION

Operator(s) L. SHOAFF
Equipment Address: USGS, Denver
Logger type: No.
Tool type:
Detector type: Scintillation
Source type: Am Be 241
Source size: 3 C; MC
Source spacing: 13 in.
Tool length, cable head to detector 7 ft in
Calibration: see Log cps
Logging speed: 17 ft/min up down
Log vert. scale: 10 ft/in

MODULE SETTINGS

Scale switch (rate or counts): 100 (cps) chart div (or) API (full scale) (circle as applicable)

T. C. switch: 4 sec.
Position Pot. (Base, zero, or (suppression)): 9.52 Dial Div.
Sensitivity Pot. (Span): 3.84 Dial Div.
Discrimination Pot.: 5 Dial Div.
Input pulse: 1.5 volts; Polarity POS.
Output switch: (normal) reverse
Actual scale: cps chart div (or) API full scale (circle as applicable)

RECORDER SETTINGS

	Ch 1	Ch 2	Ch 3
Position Pot.:	5.18		
Sensitivity Pot.:	5.00		

Run No. 1 of 1

Remarks:

WELL INFORMATION

Well No. (USGS): GNW-1
Other:
Map or Quad Gould NW Quad
Site description T. 8 N. R. 78 W., Sec 10 SW 1/4 NE 1/4
Agency or Owner:
Address:
Altitude of L.S.
Log M.P. Log TD 108 ft
Btm log interval: ft
Top log interval: ft Well TD: 115 ft
Type of finish:
Casing: Elev. of top ft/in Above Below L.S.

I.D. , from to , type
I.D. , from to , type
I.D. , from to , type

Cement: from to

Perf. interval(s) from to , type
Open hole diameter: from to
from to

Fluid level: 10 (ft) in Above At (L.S.), Top Csg (Below)

Fluid type: WATER . temp °F, °C
Fluid resist.: ohm-m
Driller: STEVE ROBERTS
Address: USGS, Denver
Type of rig: ROTARY
Date started: 7-2-79 completed 7-3-79
Aquifer or formation:

NOTE: This log is not to be used to fulfill private contractual obligations.

Other data and logs available for this well:

GPO 843-099