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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Preliminary report on the geology, geophysics and hydrology of USBM/AEC Colorado core hole No. 2, Piceance Creek Basin, Rio Blanco County, Colorado*

By

John R. Ege, R. D. Carroll, and F. A. Welder

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey format and nomenclature.

*Prepared on behalf of the U.S. Atomic Energy Commission.

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UNITED STATES
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PRELIMINARY REPORT ON THE GEOLOGY, GEOPHYSICS, AND HYDROLOGY OF USBM/AEC COLORADO CORE HOLE NO. 2, PICEANCE CREEK BASIN, RIO BLANCO COUNTY, COLORADO

By

John R. Ege, R. D. Carroll, and F. A. Welder

Abstract

Approximately 1,400 feet of continuous core was taken between 800-2,214 feet in depth from USBM/AEC Colorado core hole No. 2. The drill site is located in the Piceance Creek basin, Rio Blanco County, Colorado. From ground surface the drill hole penetrated 1,120 feet of the Evacuation Creek Member and 1,094 feet of oil shale in the Parachute Creek Member of the Green River Formation. Oil shale yielding more than 20 gallons per ton occurs between 1,260-2,214 feet in depth. A gas explosion near the bottom of the hole resulted in abandonment of the exploratory hole which was still in oil shale. The top of the nahcolite zone is at 1,693 feet. Below this depth the core contains common to abundant amounts of sodium bicarbonate salt intermixed with oil shale. The core is divided into seven structural zones that reflect changes in joint intensity, core loss and broken core due to natural causes. The zone of poor core recovery is in the interval between 1,300-1,450 feet.

Results of preliminary geophysical log analyses indicate that oil yields determined by Fischer assay compare favorably with yields determined by geophysical log analyses. There is strong evidence that analyses of complete core data from Colorado core holes No. 1 and No. 2 reveal a reliable relationship between geophysical log response and oil yield.

The quality of the logs is poor in the rich shale section and the possibility of repeating the logging program should be considered.

Observations during drilling, coring, and hydrologic testing of USBM/AEC Colorado core hole No. 2 reveal that the Parachute Creek Member of the Green River Formation is the principal aquifer and the

water in the Parachute Creek Member is under artesian pressure. The upper part of the aquifer has a higher hydrostatic head than, and is hydrologically separated from, the lower part of the aquifer. The transmissibility of the aquifer is about 3500 gpd per foot. The maximum water yield of the core hole during testing was about 500 gpm. Chemical analyses of water samples indicate that the content of dissolved solids is low, the principal ions being sodium and bicarbonate. Although the hole was originally cored to a depth of 2,214 feet, the present depth is about 2,100 feet.

This report presents a preliminary evaluation of core examination, geophysical log interpretation and hydrological tests from the USBM/AEC Colorado core hole No. 2. The cooperation of the U.S. Bureau of Mines is gratefully acknowledged. The reader is referred to Carroll and others (1967) for comparison of USBM/AEC Colorado core hole No. 1 with USBM/AEC Colorado core hole No. 2.

GEOLOGY

By

John R. Ege

Introduction

The San Francisco office of the Atomic Energy Commission (AEC/SAN) requested that the U.S. Geological Survey investigate and interpret the geologic, geophysical and hydrologic conditions at the USBM/AEC Colorado core hole No. 2 site. The location of the drill hole is in the SW 1/4, NW 1/4, NE 1/4 sec. 14, T. 1 S., R. 99 W. at a ground elevation of 6,597 feet above sea level (fig. 1). The 6-3/4-inch hole, drilled to a total depth of 2,214 feet, had 100 percent core taken below 800 feet. A gas explosion near the bottom of the hole resulted in abandonment of the site. Unfortunately the exploratory hole did not penetrate the total thickness of the oil shale section.

Lithology of core

Approximately 1,400 feet of core, taken between depths of 800-2,214 feet, were examined (table 1). The core consists of marlstone with varying amounts of kerogen, siltstone, sandstone, and occasional tuff. Common to abundant amounts of nahcolite (sodium bicarbonate salt) occur below 1,693 feet; however, indications of nahcolite and nahcolite vugs appear in sparse quantity below 1,100 feet in depth. The color of the core ranges from yellowish

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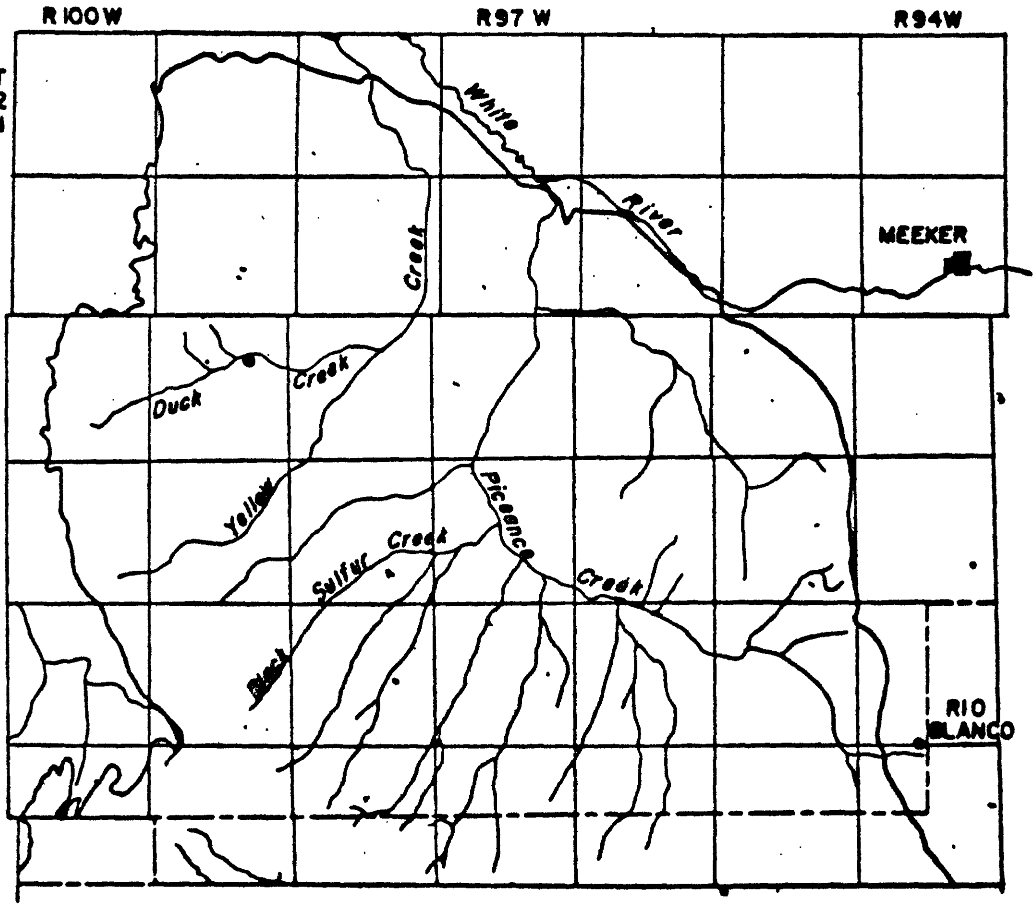

0 2 4 6 MILES

● USBM/AEC Colo. hole No. 2

Outline of Green River formation

Figure 1.--Location of USBM/AEC Colorado core hole No. 2, Rio Blanco County, Colorado

gray through pale brown to dusky brown. Oil shale in the Piceance Creek basin is defined as kerogenous marlstone that yields at least 3 gallons of shale oil per ton of rock (L. Trudell, USBM oral commun., 1966).

The continuous oil shale section in the core starts at about 1,120 feet in depth, the approximate contact between the Evacuation Creek Member and Parachute Creek Member of the Green River Formation of Eocene age. The overlying Evacuation Creek Member consists generally of siliceous sandstone, siltstone and shale. The Parachute Creek Member consists generally of marlstone. The bulk of the oil shale section is in the Parachute Creek Member. The top of the rich oil shale, that is the oil shale yielding more than 20 gallons per ton, is at 1,260 feet. Two distinctive and commonly used geophysical horizons, the A and B markers, occur at depths of 1,220 and 1,405 feet, respectively (fig. 3).

The "nahcolite zone" or zone of abundant sodium bicarbonate salt begins at a depth of 1,693 feet (table 1). The nahcolite occurs mostly as radiating crystals in vugs as much as 6 inches in diameter. At 1,998 feet there is a 6-inch bed of nahcolite, and between 1,828-1,950 feet there is an interval of generally sparse nahcolite. Vugs in sparse quantity also occur between 1,100-1,693 feet, however, most of them contain no nahcolite. Apparently the nahcolite from 1,100-1,693 feet has been removed, possibly by solution.

Joint fillings consist of carbonate, pyrite, and iron oxide. Pyrite occurs between 1,050-1,600 feet in depth. Iron oxide staining is found in the interval between 1,100-1,550 feet and carbonate filling occurs between 1,700-2,000 feet in depth. Table 1 presents a lithologic summary of the USBM/AEC Colorado core hole No. 2.

Structural and engineering properties of the core

Criteria used to describe the structural and engineering properties of the core are joint frequency, joint orientation, core loss and broken rock caused by faults, shears or closely spaced joints. Arbitrary division of the core into 50-foot intervals, beginning at 800 feet in depth, established logging units that form the basis for lithologic description and structural and engineering property calculations as shown in table 1.

The "index number," a summation of the joint frequency, core loss, and broken core into one significant number, describes the engineering character of the core (tables 1 and 2). In effect, an increasing value of the index number indicates a corresponding increase in joint frequency, core loss, and broken core and, therefore, decreasing structural competency.

Figure 2 shows the index numbers for each logged 50-foot core interval plotted as a cumulative percent curve. As the core is lithologically nearly homogeneous, differentiation of the rock depends

Table 2.--Engineering properties of subunits A through G, USBM/AEC Colorado core hole No. 2, Rio Blanco County, Colorado

Sub-unit	Core interval [1] (feet)	Thickness (feet)	Average joint frequency (Joints/foot)	Average percent of broken core <3-inch pieces (percent)	Average percent of core loss (percent)	Average index number (index number = joint frequency + 0.1 percent broken core + 0.1 percent core loss)
A	800-1,100	300	0.5	34	3	0.5 + 3.4 + 0.3 = 4.2
B	1,100-1,200	100	0.5	3	0	0.5 + 0.3 + 0 = 0.8
C	1,200-1,300	100	0.6	25	2	0.6 + 2.5 + 0.2 = 3.3
D	1,300-1,450	150	0.5	63	23	0.5 + 6.3 + 2.3 = 9.1
E	1,450-1,700	250	0.6	24	7	0.6 + 2.4 + 0.7 = 3.7
F	1,700-2,000	300	0.6	5	13	0.6 + 0.5 + 1.3 = 2.4
G	2,000-2,200	200	0.4	2	1	0.4 + 0.2 + 0.1 = 0.7

1/ Arbitrary 50-foot intervals

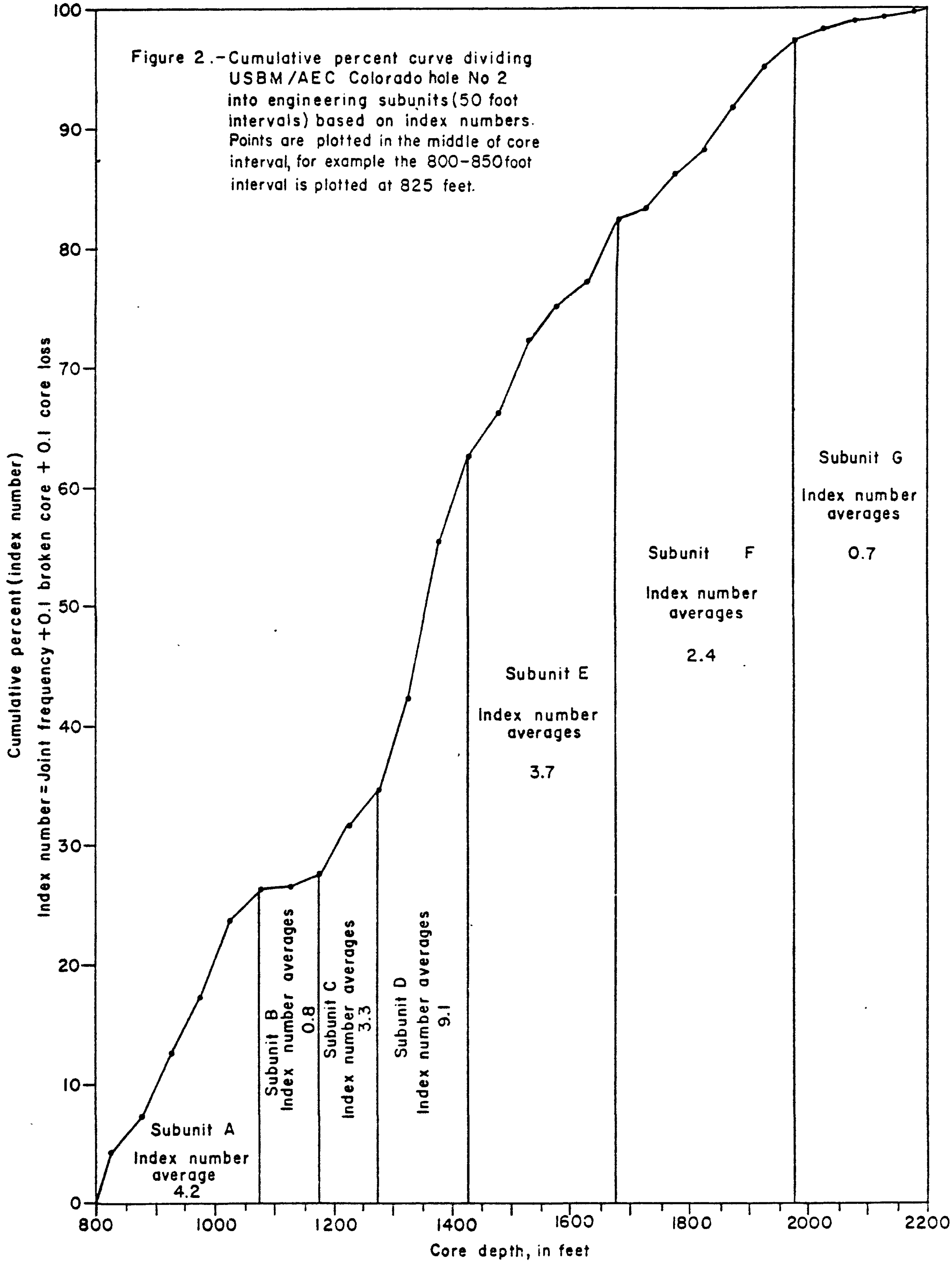

Figure 2.–Cumulative percent curve dividing USBM/AEC Colorado hole No 2 into engineering subunits (50 foot intervals) based on index numbers. Points are plotted in the middle of core interval, for example the 800–850 foot interval is plotted at 825 feet.

mainly on its structural condition. By noting changes in slope of the cumulative percent curve, one can divide the core into subunits, referred to as engineering units, which classify the rock according to its structural condition. Figure 2 shows that the USBM/AEC Colorado core hole No. 2 core has seven engineering units, A-G, indicating seven changes in engineering properties of the rock between 800-2,200 feet in depth.

Subunit A (800-1,100 feet) has an index number of 4.2. It is characterized by a relatively high percentage (34 percent) of broken core. This subunit is in the Evacuation Creek Member and consists largely of siliceous, sometimes friable, siltstone and shale. Subunit B (1,100-1,200) has an index number of 0.8 and is generally competent: joint spacing averages 6 inches and about one-half of the recorded joints are bedding plane joints that dip less than 5° from the horizontal. This subunit straddles the Evacuation Creek-Parachute Creek contact and includes the uppermost part of the oil shale. Subunit C (1,200-1,300 feet) has an index number of 3.3 and is similar to subunit A in that it has a relatively high percentage of broken core (25 percent). The Mahogany Marker, a diagnostic tuff bed is in this subunit. Subunit D (1,300-1,450 feet) has an index number of 9.1 and is characterized by a high percentage of core loss (23 percent) and broken core (63 percent). This interval may correspond to the "zone of poor recovery" found in drill holes elsewhere in the Piceance Creek basin (K. E. Stanfield, USBM, oral commun., 1966). Subunit E (1,450-1,700 feet) has an index number of 3.7. It is similar to subunit C except that it has a slightly higher core loss. Subunit F (1,700-2,000 feet) has an index number of 2.4 and is characterized by a moderate amount of core loss (13 percent) and low percentage of broken core (5 percent). Subunit F lies in the upper part of the zone of abundant nahcolite. The core loss may be due to leaching of the nahcolite from the rock by ground water. The interval contains abundant nahcolite vugs many of which are barren. Subunit G has an index number of 0.7 and is in very competent rock from which many unbroken core lengths of at least 5 feet were recovered. G also lies in the zone of abundant nahcolite; 6-inch vugs containing radiating salt crystals are characteristic of this unit. Table 2 summarizes the engineering and structural condition of the core.

GEOPHYSICS

By

R. D. Carroll

Introduction

Geophysical logs were obtained to a depth of 2,157 feet in the USBM/AEC Colorado core hole No. 2. The logs and other pertinent characteristics of the formations penetrated are shown in figure 3. All depths mentioned in this section refer to the depths shown in figure 3. These log-reference depths are 11 feet greater than the true depth below ground level because the logs were referenced to the Kelly bushing on the drill rig.

The logs reflect certain objectionable features in quality control; specifically insufficient sensitivity of the caliper log run with the sonic log, the complete insensitivity of the neutron log response in the rich oil shale section, and the absence of a logging speed notation on the density log.

Detailed analyses of all data pertinent to log interpretation in USBM/AEC Colorado core hole No. 1 and USBM/AEC Colorado core hole No. 2 are not yet available. However, there are certain salient features on the logs which deserve discussion.

Resistivity logs

The resistivity logs (induction and laterolog), in theory, respond to the presence of moisture in the formation, other things being equal. Because the apparent moisture content is considered extremely low in many intervals, the response shown on these logs requires some discussion.

The induction log in oil shale has been considered by Bardsley and Algermissen (1963) to record abnormally low values of resistivity considering the water content of the oil shale. They attribute this phenomenon to the fact that the response of the induction log does not discriminate between interbeds as thin as those that exist in portions of the oil shale. This results in a concentration of current in the more conductive zones, yielding abnormally high apparent conductivities on the log.

The bed resolution of the induction log is about 40 inches, whereas the laterolog run in USBM/AEC Colorado core hole No. 2 has a bed-thickness resolution of about 12 inches. Because the former log measures conductivity and records the reciprocal (resistivity), the response becomes less sensitive as resistivity increases. The recorded value consequently becomes asymptotic at high resistivities, resulting in "flat-topping" which can be seen in figure 3 to occur at about 570 ohm-meters on the induction log. Because of the generally high resistivities encountered in sections of the oil shale, this type of record is typical on induction logs run in the oil shale in the Piceance Creek Basin.

A careful scrutiny of the logs indicates that differences between the responses of the induction log and laterolog are only apparent, and are caused chiefly by the visual effect of the difference in scale sensitivity. Detailed examination indicates that both electric logs probably reflect moisture differences in thin sections and, although the laterolog has a greater bed thickness resolution (1 foot) than the induction log (40 inches), either log adequately defines the changes in resistivity throughout the section. The coincidence of the values of the resistivities indicated by the electric logs in the low resistivity zones indicates the log response is probably not a result of inadequate bed resolution.

It is concluded that the low resistivity zones are caused by response of the electric logs to the effects of moisture in the section. The conclusions reached by Bardsley and Algermissen on the response of the induction log are not considered applicable in this hole.

Above 1,650 feet the more prominent low-resistivity zones in the continuous oil-shale section represent intervals of lean shale, generally assaying less than 7 gallons/ton. The log response is probably due to the presence of some moisture in the pores of the rock in these intervals. Prominent resistivity lows on the laterolog below that depth are not similarly correlatable. It is probable that the relatively low-resistivity excursions in these intervals, may represent the effect of water contained in fractures.

Because of the less sensitive resistivity scale of the laterolog (100 ohm-meters on half a trace as opposed to a full trace for the same deflection on the induction log) geologic "noise" is suppressed and the B groove at 1,400 feet is more evident on this log (fig. 3).

Radiation logs

Gamma-ray log

The observation by Bardsley and Algermissen (1963) that the response of the gamma-ray log is, in a qualitative manner, inversely related to the yield of oil-shale, is supported by the response of this log in the USBM/AEC Colorado core hole No. 2.

A comparison of three available gamma-ray logs in the oil-shale section (USBM/AEC Colorado core hole No. 1, USBM/AEC Colorado core hole No. 2, and Texaco's Fawn Creek unit No. 3, sec. 27, T. 3 S., R. 98 W.) indicates that an easily recognizable correlation zone exists on these logs: in USBM/AEC Colorado core hole No. 2, it is the high-radiation zone 1,340 to 1,720 feet (fig. 3). The small high-radiation precursor (1,340-1,375) that initiates this zone and the high gamma-ray kick that indicates the Black Marker are also typical of this zone on the other gamma-ray logs examined (compare 1,190-1,740 feet) in the USBM/AEC Colorado core hole No. 1 (Carroll and others, 1965). In referencing the B groove, the gamma-ray log may be worth considering in lieu of the electric log for character correlation.

Neutron log

Because of the improper selection of scales mentioned earlier, the neutron log is not usable in the rich oil shale section below 1,380 feet. Above 1,380 feet a gross correlation seems to exist between increased neutron count rate and decreased oil yield as observed by Bardsley and Algermissen (1963).

Determinations of oil yield

Assays of oil yield (table 3) were made in the shale section based on density and velocity logs, using methods previously reported (Carroll and others, 1967). The density and sonic logs obtained in the present hole, however, were affected to a greater extent by adverse local conditions than those obtained in the USBM/AEC Colorado core hole No. 1. This is due to a combination of borehole rugosity and thin interbeds in the rich shale section. These conditions cause a log response that, in general, tends to give optimistic values for the oil yield in this interval.

Abrupt changes in the diameter of the hole cause the sonic and density logs to read lower than the true value. "Compensation" devices in these intervals are not reliable, and when interpreting, the interval should be either ignored or evaluated using "smoothing" or other techniques. Log interpretation in these cases becomes a matter of judgement based on experience. An example may be found in the interval below 2,100 feet in USBM/AEC Colorado core hole No. 2, which is highly caved as a result of a gas explosion during drilling (fig. 3). In this interval the density log recorded values close to the density of water in several places, although a compensation correction is indicated which gives the erroneous impression that a valid density may be obtained. The nature of commercial density-logging equipment at present is such that a density value interpreted for this caved interval could only be an educated guess based upon the response in a relatively uniform interval, for example, the interval between 2,150-2,165 feet. Other examples of zones where density interpretations are not valid occur at 1,988 feet and 2,001 feet. At these depths the caliper log is not sufficiently sensitive to detect the caved intervals. Whenever one notes triangular-shaped responses on the caliper log, such as those near the bottom of the log in this hole, it is advisable to check a number of other logs to be sure that extensive caving has not occurred which is only suggested by the response of the caliper log.

The response of density logs is so sensitive to hole-diameter changes that in future oil-shale evaluation logging it is advisable that a three-arm caliper be used rather than a bow-spring caliper tool. Hole-diameter changes also adversely affect the sonic-log response by causing cycle skipping resulting from time delays in triggering. Other factors affecting these logs are the thickness, and the density and velocity contrasts of the beds. The sonic log run in USBM/AEC Colorado core hole No. 2 has an ideal bed resolution of 2 feet. Consequently, beds less than 2 feet thick will yield values of apparent-velocity higher or lower than the true velocity depending on the velocity of surrounding beds. A dual-receiver sonic log with a 1-foot receiver spacing is preferable to a 2-foot receiver spacing in the oil shale.

The response of the density log in thin beds is also dependent on instrument time-constant and logging speed as well as thickness and density contrast. Difficulties involving these features were encountered in attempting to interpret the logs in the basal portion of the hole. However, it was possible to use geophysical logs to estimate oil yields throughout most of the hole.

Table 3 presents a comparison of oil assays obtained by log-interpretation methods with Fischer assay data supplied by the Bureau of Mines. The Fischer assays listed in table 3 are unweighted averages of values obtained over 10-foot intervals throughout the section. It is felt that this procedure furnishes a good first approximation of the accuracy of the interpretation method. A more exhaustive examination will be made when assay data from USBM/AEC Colorado core hole No. 1 are available.

The oil yield in the continuous oil-shale section, as determined from the geophysical logs, compares favorably with the Fischer assay data to a first approximation. The response of the logs certainly

Table 3.--Comparison of yield of oil shale as determined from geophysical logs with Fischer in USBM/AEC Colorado core hole No. 2

Interval 1/ (feet)	Length (feet)	Average log-indicated density (gms/cc)	Average log-indicated sonic travel time (µsec/ft)	Oil yield in gallons/ton based on data of: Smith density	Bardsley and Algermissen: Density	Bardsley and Algermissen: Sonic travel time	Fischer retort analyses 2/	Remarks
1,000-1,068	68	2.37	76.5	15.8	15.8	7.3	6.8	
1,068-1,130	62	2.19	100.3	27.0	25.2	24.5	3.4	Top of continuous oil shale at 1,120.
1,130-1,260	130	2.30	84.4	19.8	18.1	12.5	12.0	
1,260-1,580	320	2.17	101.8	28.3	26.5	25.8	24.7 3/	
1,580-1,710	130	2.24	103.2	23.6	22.0	26.8	20.3	
1,710-1,870	160	1.98	123	42.5	38.9	45.4	37.2	Indications on logs that hole is more rugose than is indicated by caliper logs.
1,870-2,110	240	(?)	115?	(?)	(?)	37.5?	36.3	Highly erratic log response due to combination of thin beds and hole rugosity. Gross estimate based on "smoothing." Logs indicate hole is more rugose than indicated by caliper logs.
2,110-2,160	50	No valid interpretation possible due to caved hole					37.5	

Footnotes on p. 19

Footnotes to table 3.

1/ Depth reference (geophysical log) 11 feet above ground level; subtract 11 feet for true depth.

2/ Based on unweighted averages of core over 10-foot intervals.

3/ Based on assumed 4 gal/ton average assay in B groove which was not Fischer-assayed. Average retort analyses exclusive of B groove is 14.7 gal/ton.

indicates that a more detailed analysis of all log and core data from USBM/AEC Colorado core holes No. 1 and No. 2 may be expected to contribute to the development of a more reliable method of obtaining an estimate of oil yield.

The first two intervals listed in table 3, although above the continuous oil-shale section, are included because they were arbitrarily evaluated in the preliminary estimate of the yield which was submitted by letter to those concerned. The interval below 1,710 feet has also been reexamined.

The oil-yield comparisons data in table 3 tend to corroborate the analyses of Bardsley and Algermissen. However, an extensive evaluation of a thick section of oil shale in an area of thick overburden (such as existed in USBM/AEC Colorado core holes No. 1 and No. 2) is desirable because Bardsley and Algermissen's data were obtained from only 300 feet of oil shale near the surface. The only other log analyses of oil yield published (Baldwin and others, 1966) were restricted to an oil-shale section of less than 100 feet thick and relied upon the relationships established by Bardsley and Algermissen to calibrate the density logs used in the study. The oil-yield obtained by Baldwin and others (1966) was consistently lower than the yields shown by the Fischer assay. On the other hand, it will be noted that the log-determined oil yields given in table 3 are consistently higher than the yields determined by Fischer retort analyses.

The fact that the oil yields determined using Smith's density relationship (Smith, 1958) are higher than those obtained by the other methods does not necessarily imply the inappropriateness of Smith's equation because density log responses should be calibrated in the media of interest. A comparison of actual core densities with densities determined from density logs is required. Smith (oral commun., 1966) also considers it possible that accessory minerals in the oil shale, for example nahcolite, may yield erroneous assays based on density-oil yield relationships.

In summary, the geophysical log data appear to indicate the following:

(1) A more detailed examination of core data and log data is desirable when complete data from USBM/AEC Colorado core hole No. 1 and USBM/AEC Colorado core hole No. 2 are available.

(2) The possibility of obtaining a reliable relationship between oil yield (as well as other significant parameters) and geophysical logs in the oil shale is strongly suggested.

(3) Extreme care must be exercised in logging oil-shale holes and in controlling quality of the logs.

(4) If possible, a more sensitive caliper log should be obtained in the oil-shale section below 1,700 feet in USBM/AEC Colorado core hole No. 2. If the results indicate that the hole is not excessively caved, relogging for density and sonic velocity with slower logging speeds should be attempted.

(5) The poor quality of the logs in the oil-rich shale section in USBM/AEC Colorado core hole No. 2, negates to a large extent, meaningful interpretations in this section.

HYDROLOGY

By

F. A. Welder

Introduction

Drilling of the USBM/AEC Colorado core hole No. 2 began June 24, 1966, using compressed air at 90 psi. Air, cuttings, and fluid were discharged through a horizontal pipe 80 feet long and 6 inches in diameter. The hole was dry to 307 feet, where the cuttings became damp enough to plug the hole. Air pressure was then increased to 300 psi, and a mixture of soap and water was injected at about 3 gpm. This rate of water injection was maintained until total depth was reached except while water samples were being collected or discharge was being measured. The upper 411 feet of the hole is cased with 7-5/8-inch (O.D.) steel pipe.

The first noticeable discharge of ground water during drilling, about 1 gpm, was at 447 feet (table 4). Between 957 and 1,026 feet, the discharge increased from 30 to 153 gpm, as measured by a container and stop watch. During drilling below 1,161 feet, discharge was measured by a 9-inch Parshall flume 100 feet downhill from the end of the discharge pipe. Because of leakage, evaporation, and infiltration, discharge figures obtained with the flume may be 10 percent low.

Discharge rate, temperature, and specific conductance of water discharged with the cuttings were plotted against well depth (fig. 4).

Table 4.--Specific conductance, temperature and discharge rate of water during coring of USBM/AEC Colorado core hole No. 2
(Dash (-) shows that measurement was not made)

Date 1966	Well depth below Kelly bushing (ft)	Specific conductance micromhos per cm	Temp. (°F)	Discharge (gpm)	Other
6-25	447	1500	-	1	First water.
6-26	805	1000	57	25	150-minute recovery shows transmissibility less than 100 gpd per ft.
6-28	957	950	63	30	
6-29	1026	1000	63	153	
6-29	1032	1100	63	260	
6-30	1161	960	65	220	Installed 9-inch flume. Some water is lost by evaporation, leakage, and infiltration.
7-2	1211	975	64	250	
7-2	1290	875	65	315	
7-4	1385	990	68		
7-5	1423	990	67	420	
7-5	1456	950	69	435	Static water level about 290 ft below KB.
7-6	1517	990	68	460	
7-7	1570	1000	70	460	
7-8	1673	1000	69	490	
7-9	1758	1000	70	460	
7-10	1857	1000	70	450	
7-12	1990	1650	73	460	Water contains some gas.
7-13	1990	-	-	-	Static water level 315 ft below KB. 7 hours not pumping.
7-13	2089	1900	74	510	
7-14	2214	-	-	-	Total depth--unable to log below 2169 on 7-17-66.
7-17	2169-2214	-	-	-	Static water level 314 ft below KB after 10 hrs of no pumping. Started pumping test at 9:30 AM.
7-17	2169-2214	2200	76	450	After 7 hours of pumping recovery was started at 4:30 PM.

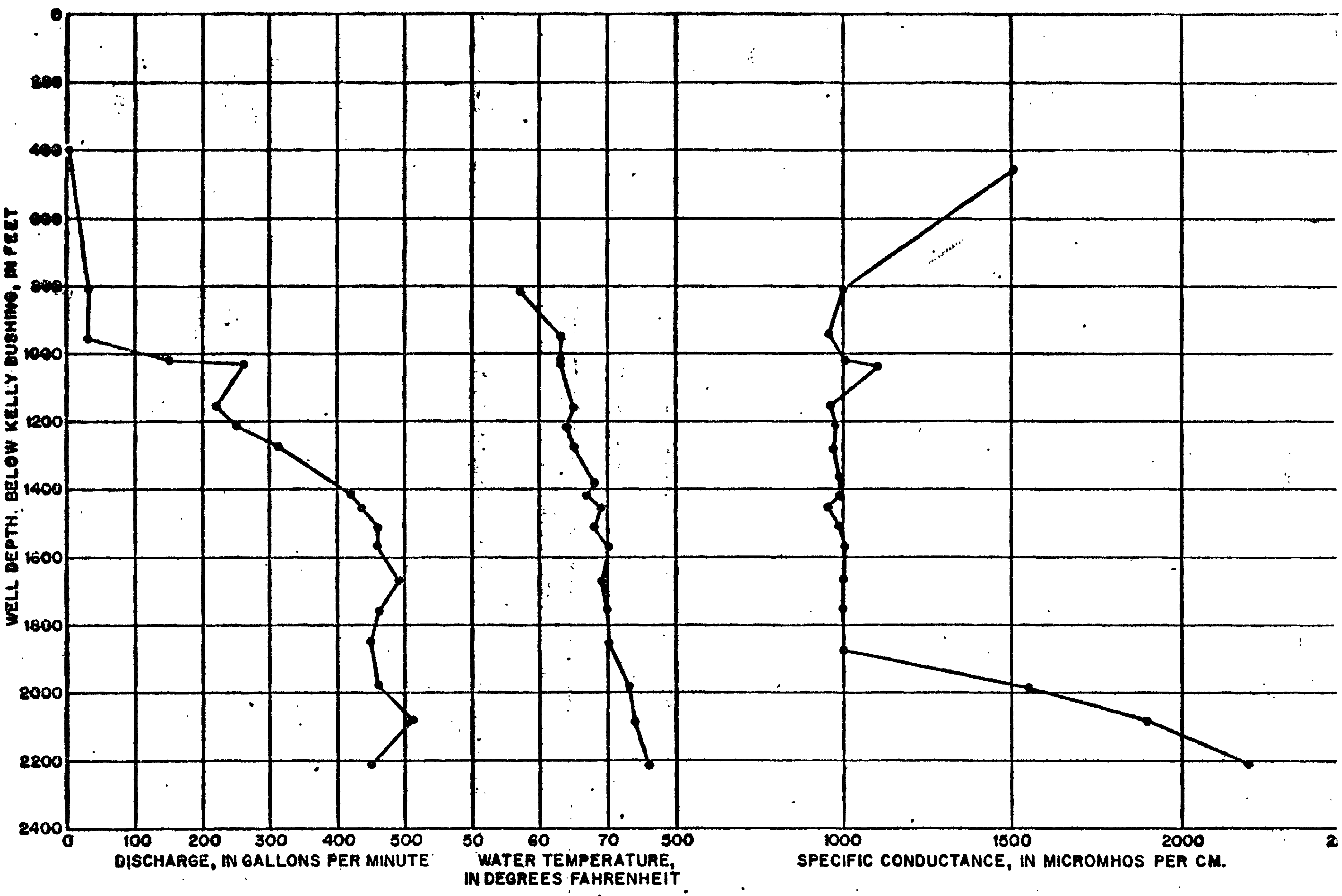

FIGURE 4.- Graph showing relation of water discharge, water temperature, and specific conductance to well depth, U.S.B.M./A.E.C. Colorado core hole N

Between depths of 957 and 1,673 feet, the rate of increase of discharge was greatest. During drilling below 1,673 feet, the rate of discharge remained fairly constant--although water was entering the hole below 1,673 feet, as indicated by the rise in water temperature and specific conductance with depth.

The hole was cored to 2,214 feet, but the explosion near the bottom of the hole caused a cave-in. Coring was stopped after the explosion, but geophysical logging was subsequently completed, showing a depth of 2,169 feet. On August 21, 1966, the current-meter survey showed a depth of 2,100± feet.

The well was pumped by compressed air under 500 psi for 7 hours on July 17, 1966. After the compressors were turned off, water-level recovery was measured at regular intervals for 1,000 minutes. The water level was plotted against the log of time elapsed since pumping ceased (fig. 5) and the transmissibility was computed to be 2,400 gpd per foot.

Pumping tests using packers

From August 27 to August 30, 1966, pumping tests were made using two packers to seal off a 300-foot section of the hole. A Reda submergible pump was set 5 feet below the top packer and pumped from the interval between packers. Pumping tests were made under the following conditions: No. 1, packers set at depths of 900 and 1,200 feet; No. 2, packers set at depths of 1,198 and 1,498 feet; No. 3, upper

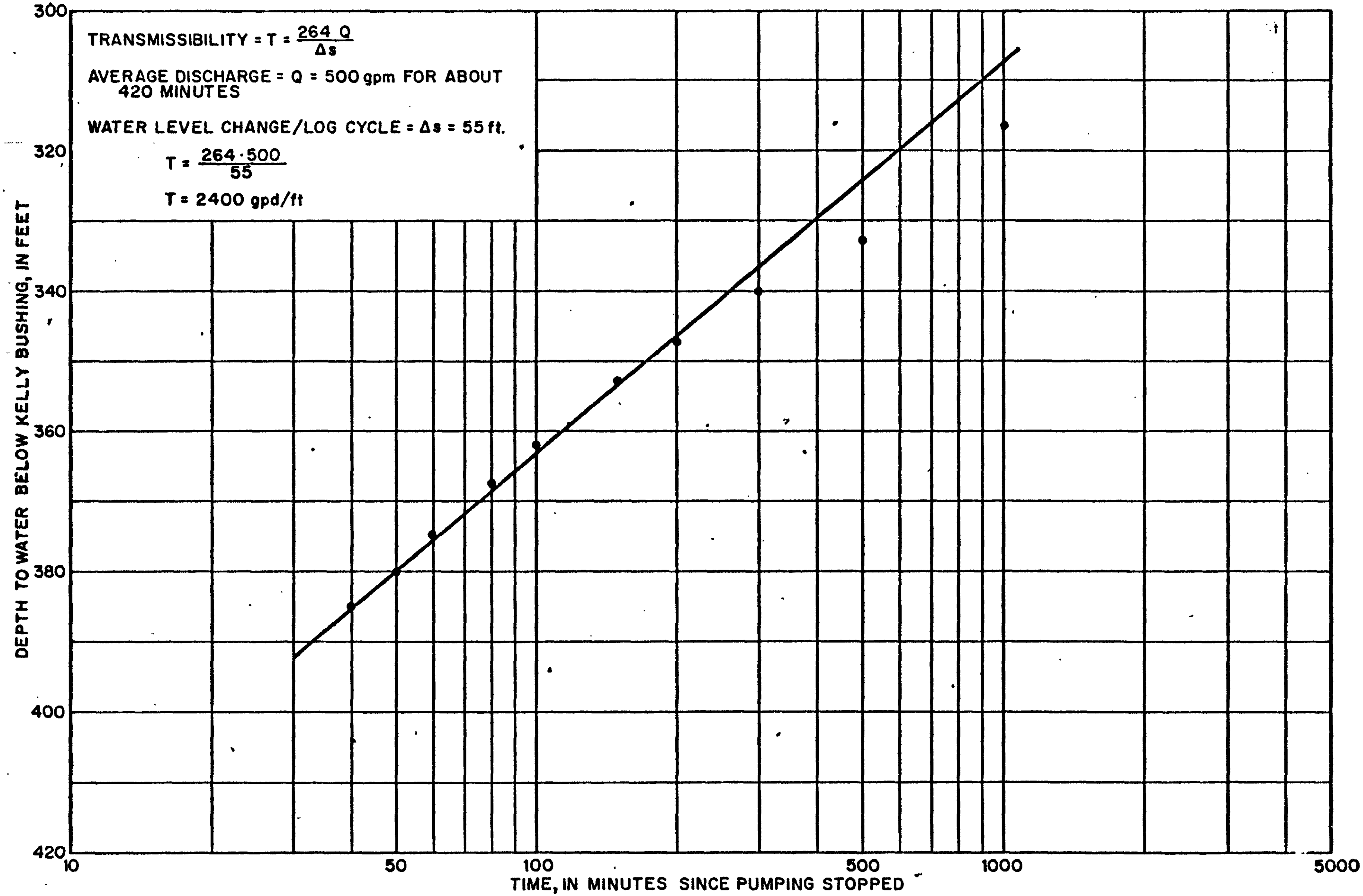

FIGURE 5.-Semilogarithmic graph of recovery data, after pumping open hole between casing and total depth (411'-2100'±) U.S.B.M./A.E.C. Colorado core hole No. 2, July 17, 1966.

packer set at 1,500, lower packer not used; No. 4, tested entire hole (below casing to total depth) without using packers. Water temperature, in degrees Fahrenheit, and specific conductance in micromhos per centimeter were taken periodically throughout each test.

Test No. 1.--Packers set at 900 and 1,200 feet. Water-level measurements were made in the zone between the bottom of the casing and the upper packer (411-900 feet), in the zone between the packers (900-1,200 feet), and in the zone between the bottom packer and total depth (1,200-2,100± feet), during both the pumping and recovery phases of the test (table 5). As soon as pumping started, water levels began to fall in the zone between the bottom of the casing and the upper packer and the zone between the packers (fig. 6), indicating that there is hydraulic connection between the zones. Between 150 and 200 minutes after pumping started, the water level in the zone between the casing and the upper packer rose 26 feet.

In the zone between the bottom packer and total depth, the water began to decline slowly 8 minutes after pumping started and after 30 minutes declined rapidly. The decline continued throughout the test, probably because the lower packer shut off recharge from a higher zone.

Table 5
Water-level measurements during
test No. 1, USBM/AEC Colorado core hole No. 2
August 27, 1966

Time (min)	Zone between casing and upper packer (411- 900 ft)		Zone between packers (900-1200 ft)				Zone between bottom packer and total depth (1200 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (drawdown) (ft)	Air gauge pressure on 900 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)	Air gauge pressure on 1200 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)
a	b	c	d	e	f	g	h	i	j	k
Pump on: August 27, 1966, 11:00 a.m., average discharge, 94 gpm from zone between packers										
0	249.2	0	255	0	311	0	356	0	378	0
2	294.3	45.1	242	13	341	30	356	0	378	0
4	304.5	55.3	240	15	346	35	356	0	378	0
6	309.6	60.4	238	17	340	39	356	0	378	0
8	312.1	62.9	236	19	355	44	356	0	378	0
10	313.5	64.3	235	20	357	46	355	1	380	2
12	314.1	64.9	235	20	357	46	355	1	380	2
15	314.6	65.4	235	20	357	48	355	1	380	2
20	317.0	67.8	234	21	359	51	355	1	380	2
25	318.2	69.0	233	22	362	51	355	1	380	2
30	318.9	69.7	233	22	362	53	355	1	380	2
40	320.3	71.1	232	23	364	53	354	2	382	5
50	321.4	72.2	232	23	364	53	353	3	385	7
60	322.3	73.1	232	23	364	53	353	3	385	7

Table 5
Water-level measurements during
test No. 1, USBM/AEC Colorado core hole No. 2 (continued)
August 27, 1966

Time (min)	Zone between casing and upper packer (411 - 900 ft)		Zone between packers (900-1200 ft)				Zone between bottom packer and total depth (1200 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (drawdown) (ft)	Air gauge pressure on 900 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)	Air gauge pressure on 1200 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)
a	b	c	d	e	f	g	h	i	j	k
80	323.4	74.2	232	23	364	53	351	5	390	12
100	325.9	76.7	232	23	364	53	350	6	392	14
150	328.1	78.9	230	25	368	57	347	9	399	21
200	302.7	53.5	230	25	368	57	343	13	418	30
300	305	55.8	232	23	364	53	336	20	424	46
400	306.1	56.9	232	23	364	53	331	25	436	58
Pump off: August 27, 1966, 5:40 p.m.										
		(Residual drawdown)				(Residual drawdown)				(Residual drawdown)
0	306.1	56.9					334	22	430	51
2	292.0	42.8	232	23	364	53	333	23	432	53
4	289.8	40.6	232	23	364	53	333	23	432	53
6	288.4	39.2	232	23	364	53	333	23	432	53
8	287.6	38.4	232	23	364	53	333	23	432	53
10	286.8	37.6	232	23	364	53	333	23	432	53
12	286.2	37.0	232	23	364	53	333	23	432	53

Table 5
Water-level measurements during
test No. 1, USBM/AEC Colorado core hole No. 2 (continued)
August 27, 1966

Time (min)	Zone between casing and upper packet (411-900 ft)		Zone between packers (900-1,200 ft)				Zone between bottom packer and total depth (1,200-2,100± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (Residual drawdown) (ft)	Air gauge pressure on 900 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (Residual drawdown) (ft)	Air gauge pressure on 1,200 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (Residual drawdown) (ft)
a	b	c	d	e	f	g	h	i	j	k
15	285.5	36.3	232	23	364	53	333	23	432	53
20	284.6	35.4	232	23	364	53	331	25	436	58
25	283.9	34.7	234	21	359	51	331	25	436	58
30	283.3	34.1	234	21	359	51	331	25	436	58
40	282.4	33.2	235	20	357	48	330	26	439	60
60	281.2	32	-	-	-	-	-	-	-	-
80	280.4	31.2	235	20	357	48	327	29	445	67
100	279.8	30.6	235	20	357	48	326	30	447	69
150	278.8	29.6	235	20	357	48	326	30	447	69
200	278.2	29.0	235	20	357	48	319	37	464	85
300	277.4	28.2	235	20	357	48	312	44	480	102

NOTE: To convert air gauge pressure to depth to water in feet:

Water level in feet below measuring point = length of airline in feet - (pressure in pounds per square inch X 2.31 feet of water per pound per square inch)

Drawdown in feet of water = pressure change in pounds per square inch X 2.31 feet of water per pound per square inch.

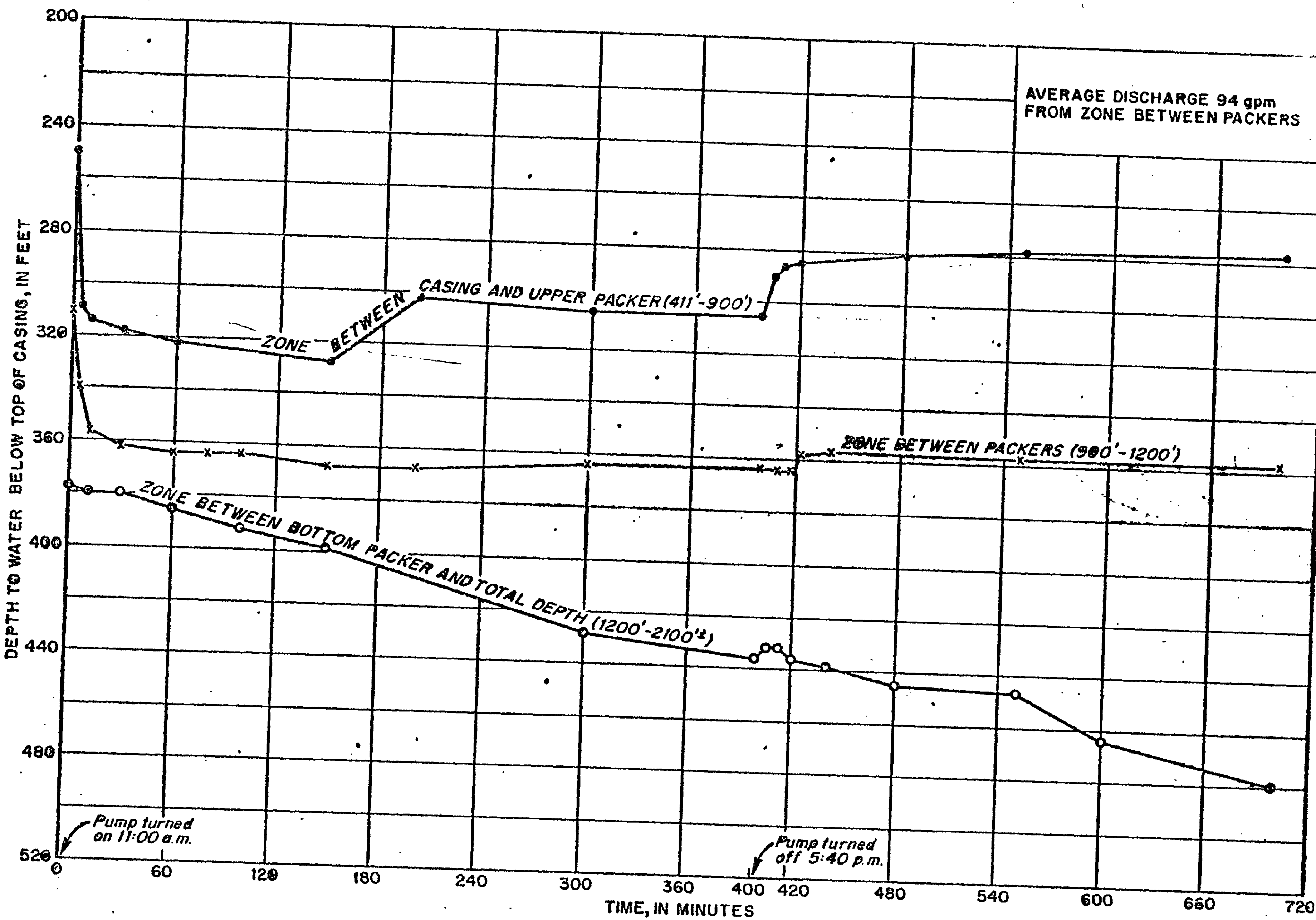

FIGURE 6.- Water-level measurements during test No. 1, U.S.B.M./A.E.C. Colorado core hole No. 2, August 27, 1966.

Well discharge, water temperature, and specific conductance are shown below:

Time in minutes since pumping started	Discharge (gpm)	Specific conductance (micromhos per cm)	Temperature (°F)
30	93.4	1,000	65
100	88.8	1,000	66
150	88.8	1,000	67
300	97.4	1,000	68
370	97.4	950	69.5
390	97.4	950	68
Average	94		

<u>Test No. 2</u>.--Packers set at 1,198 and 1,498 feet. Water-level measurements were made in the zone between the bottom of casing and the upper packer (411-1,198 feet), the zone between the packers (1,198-1,498 feet), and the zone between the bottom packer and total depth (1,498-2,100± feet), during both the pumping and recovery phases of the test (table 6).

During pumping, the water level in the zone between the bottom of the casing and the upper packer, recovered consistently (fig. 7). This was probably due to the fact that leakage from the upper zone to a lower zone was shut off by the packer. Water level in the zone between the packers declined during pumping and recovered after pumping started.

The water level in the zone between the bottom packer and total depth declined throughout the test except for a slight recovery immediately after pumping ceased. The decline probably was the result of recharge from a higher zone being shut off by the packers.

Table 6
Water-level measurements during
test No. 2, USBM/AEC Colorado core hole No. 2
August 28, 1966

Time (min)	Zone between casing and upper packer (411-1198 ft)		Zone between packers (1198-1498 ft)				Zone between bottom packer and total depth (1498 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (recovery) (ft)	Air gauge pressure on 900 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)	Air gauge pressure on 1500 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)
a	b	c	d	e	f	g	h	i	j	k
Pump on: August 28, 1966, 3:00 p.m., average discharge 88.8 gpm from zone between packers										
0	274.5	0.0	398	0	278	0	464	0	426	0
2	261.3	13.2	390	8	297	18.5	462	2	431	4.5
4	256.0	18.5	385	13	308	30	461	3	433	7
6	255.1	19.4	381	17	318	39	461	3	433	7
8	254.5	20.0	379	19	323	43	460	4	435	9
10	254.0	20.5	378	20	325	46	460	4	435	9
12	253.5	21.0	377	21	328	47	460	4	435	9
15	252.9	21.6	378	20	325	46	459	5	438	12
20	252.1	22.4	378	20	325	46	459	5	438	12
25	251.5	23.0	377	21	328	47	458	6	440	14
30	251.0	23.5	376	22	330	51	457	7	443	16
40	250.0	24.5	374	24	334	55	456	8	446	18
50	249.4	25.1	373	25	336	58	454	10	449	23

Table 6
Water-level measurements during
test No. 2, USBM/AEC Colorado core hole No. 2 (continued)
August 28, 1966

Time (min)	Zone between casing and upper packer (411-1198 ft)		Zone between packers (1198-1498 ft)				Zone between bottom packer and total depth (1498 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (recovery) (ft)	Air gauge pressure on 900 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)	Air gauge pressure on 1500 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)
a	b	c	d	e	f	g	h	i	j	k
60	248.8	25.7	372	26	339	60	453	11	451	25
80	247.9	26.6	372	26	339	60	451	13	557	30
100	247.1	27.4	372	26	339	60	450	14	458	32
150	245.8	28.7	371	27	341	62	446	18	469	42
200	244.8	29.7	369	29	346	67	440	24	483	55
250	244.0	30.5	367	31	350	72	439	25	485	58
300	243.4	31.1	365	33	354	76	435	29	490	67
						(Residual drawdown)				(Residual drawdown)
Pump off: August 28, 1966, 8:00 p.m.										
2	243.4	31.1	368	30	348	69	440	24	483	55
4	243.4	31.1	368	30	348	69	439	25	485	58
6	243.4	31.1	369	29	346	67	439	25	485	58
8	-	-	370	28	343	65	438	26	486	53
12	243.4	31.1	372	26	339	60	440	24	483	56

Table 6
Water-level measurements during
test No. 2, USBM/AEC Colorado core hole No. 2 (continued)
August 28, 1966

Time (min)	Zone between casing and upper packer (4[illegible]1-1198 ft)		Zone between packers (1198-1498 ft)				Zone between bottom packer and total depth (1498 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (recovery) (ft)	Air gauge pressure on 900 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)	Air gauge pressure on 1500 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)
a	b	c	d	e	f	g	h	i	j	k
						(residual drawdown)				(residual drawdown)
15	243.4	31.1	372	26	339	60	440	24	483	56
20	-	-	373	25	336	58	439	25	485	58
25	-	-	372	26	339	60	439	25	485	58
30	-	-	371	27	341	62	437	27	489	62
40	243.1	31.4	371	27	341	62	433	31	498	72
50	-	-	371	27	341	62	432	32	500	74
60	-	-	375	23	332	53	429	35	508	81
80	243.0	31.0	375	23	332	53	426	38	514	88
100	-	-	372	26	339	60	424	40	518	93
150	242.2	32.3	371	27	341	62	419	45	528	102
200	241.9	32.6	370	28	343	65	414	50	539	113
300	241.1	33.4	370	28	343	65	405	59	562	136

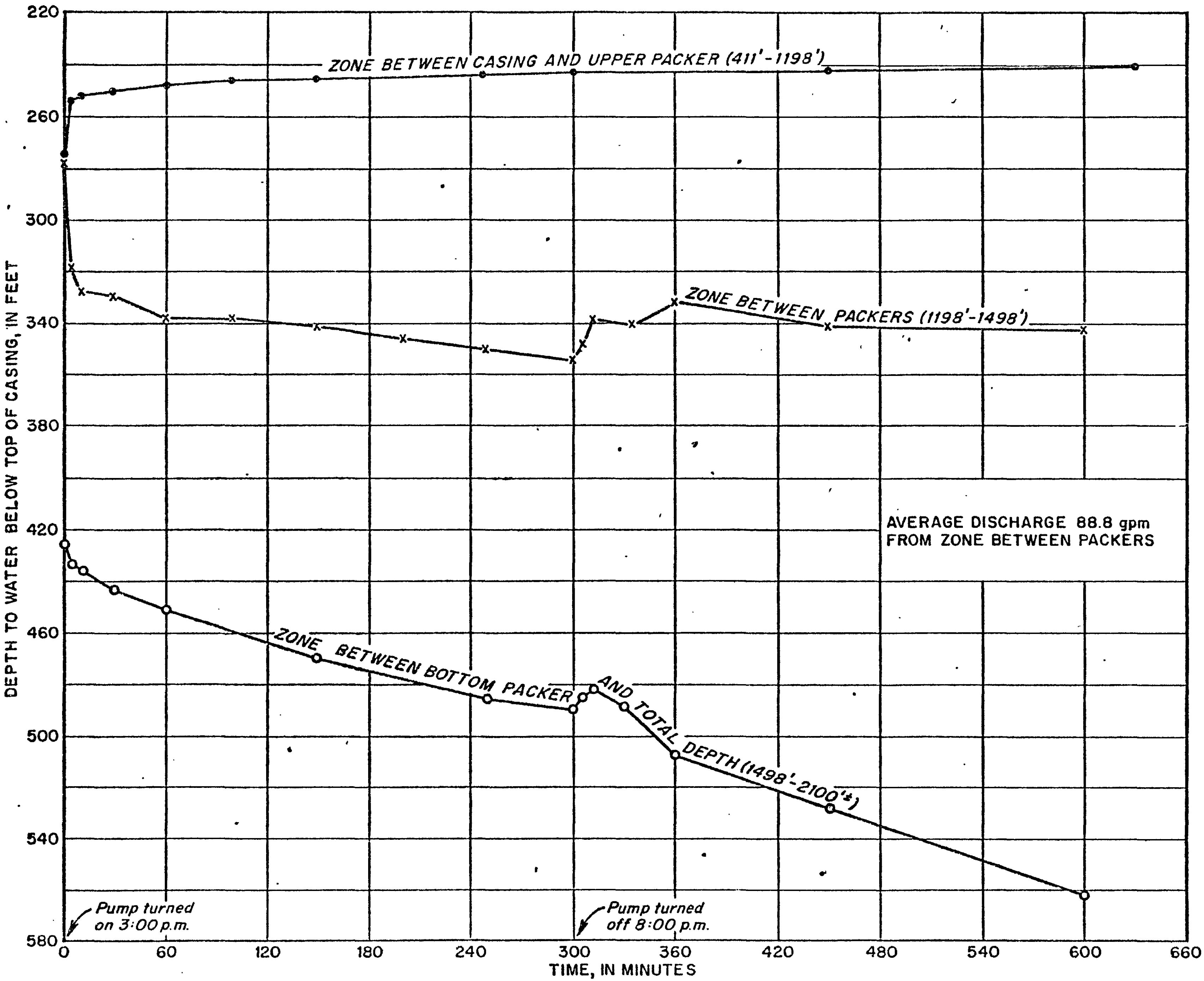

FIGURE 7.–Water-level measurements during test No. 2, U.S.B.M./A.E.C. Colorado core hole No. 2, August 28, 1966

Well discharge, water temperature, and specific conductance are shown below:

Time in minutes since pumping started	Discharge (gpm)	Specific conductance (micromhos per cm)	Temperature (°F)
15	88.8	1,000	69
30	88.8	900	70
50	88.8	950	71.5
80	88.8	950	73
150	88.8	925	74
200	---	950	73.5
290	---	900	74
Average	88.8		

<u>Test No. 3</u>.--The upper packer set at 1,500 feet, and the lower packer not used. The core hole from 1,500 to total depth was pumped during the test (table 7). Water level in the zone above the upper packer rose gradually throughout the test, suggesting that the packer was holding and that hydrologic connection was negligible (fig. 8).

Well discharge, water temperature, and specific conductance are shown below:

Time in minutes since pumping began	Discharge (gpm)	Specific conductance (micromhos per cm)	Temperature (°F)
13	84.8	950	67
23	80.3	950	68
40	80.3	950	69.5
80	72.7	1,050	71
150	72.7	950	72
250	68.7	1,000	72
300	79	1,000	73
Average	74		

Table 7
Water-level measurements during
test No. 3, USBM/AEC Colorado core hole No. 2
August 29, 1966

Time (min)	Zone between casing and upper packer (411-1500 ft)		Zone between packer and total depth (1500 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (recovery) (ft)	Air gauge pressure on 1500 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)
a	b	c	d	e	f	g
Pump on: August 29, 1966, 1:00 p.m., average discharge 74 gpm from zone between the packer and total depth.						
0	260.1	0	391	0	597	0
2	259.8	0.3	387	4	606	9
4	259.6	.5	385	6	611	14
6	259.5	.6	384	7	613	16
8	259.3	.8	383	8	616	19
10	259.1	1.0	382	9	618	21
12	259.0	1.1	382	9	618	21
15	258.8	1.3	381	10	621	23
20	258.5	1.6	381	10	621	23
25	258.2	1.9	380	11	622	25
30	258.0	2.1	379	12	625	28
40	257.5	2.6	378	13	627	30
50	257.1	3.0	377	14	629	32
60	256.8	3.3	376	15	632	35

Table 7
Water-level measurements during
test No. 3, USBM/AEC Colorado core hole No. 2 (continued)
August 29, 1966

Time (min)	Zone between casing and upper packer (411-1500 ft)		Zone between packer and total depth (1500 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (recovery) (ft)	Air gauge pressure on 1500 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (drawdown) (ft)
a	b	c	d	e	f	g
80	256.1	4.0	374.5	16.5	635	38
100	255.6	4.5	373.5	17.5	638	41
150	254.8	5.3	368	23	650	53
200	254.0	6.1	363.5	27.5	661	64
250	253.4	6.7	359.5	31.5	669	72
300	- -	- -	356	35	678	81
Pump off: August 29, 1966, 6:00 p.m						(recovery)
0	253.4	6.7	356	35	678	81
2	252.9	7.2	359	32	671	74
4	- -	- -	361	30	666	69
6	252.8	7.3	363	28	662	65
10	- -	- -	367	24	652	55
12	- -	- -	369	22	648	51
15	- -	- -	372	19	640	43
20	- -	- -	374	17	636	39

Table 7
Water-level measurements during
test No. 3, USBM/AEC Colorado core hole No. 2 (continued)
August 29, 1966

Time (min)	Zone between casing and upper packer (411-1500 ft)		Zone between packer and total depth (1500 - 2100 ± ft)			
	Electric line depth to water below measuring point (ft)	Change in water level (recovery) (ft)	Air gauge pressure on 1500 ft airline (psi)	Pressure change (psi)	Air gauge pressure converted to depth to water below measuring point (ft)	Change in water level (recovery) (ft)
a	b	c	d	e	f	g
25	252.6	7.5	376	15	632	35
30	- -	- -	378	13	627	30
40	- -	- -	382	9	618	21
50	- -	- -	383	8	616	19
60	- -	- -	384	7	613	16
80	- -	- -	385	6	611	14
100	251.8	8.3	391	0	597	0
140	- -	- -	396	5	585	12
200	251.6	8.5	397	6	583	14
250	251.2	8.9	403	12	569	28
300	250.7	9.4	408.5	17.5	556	41

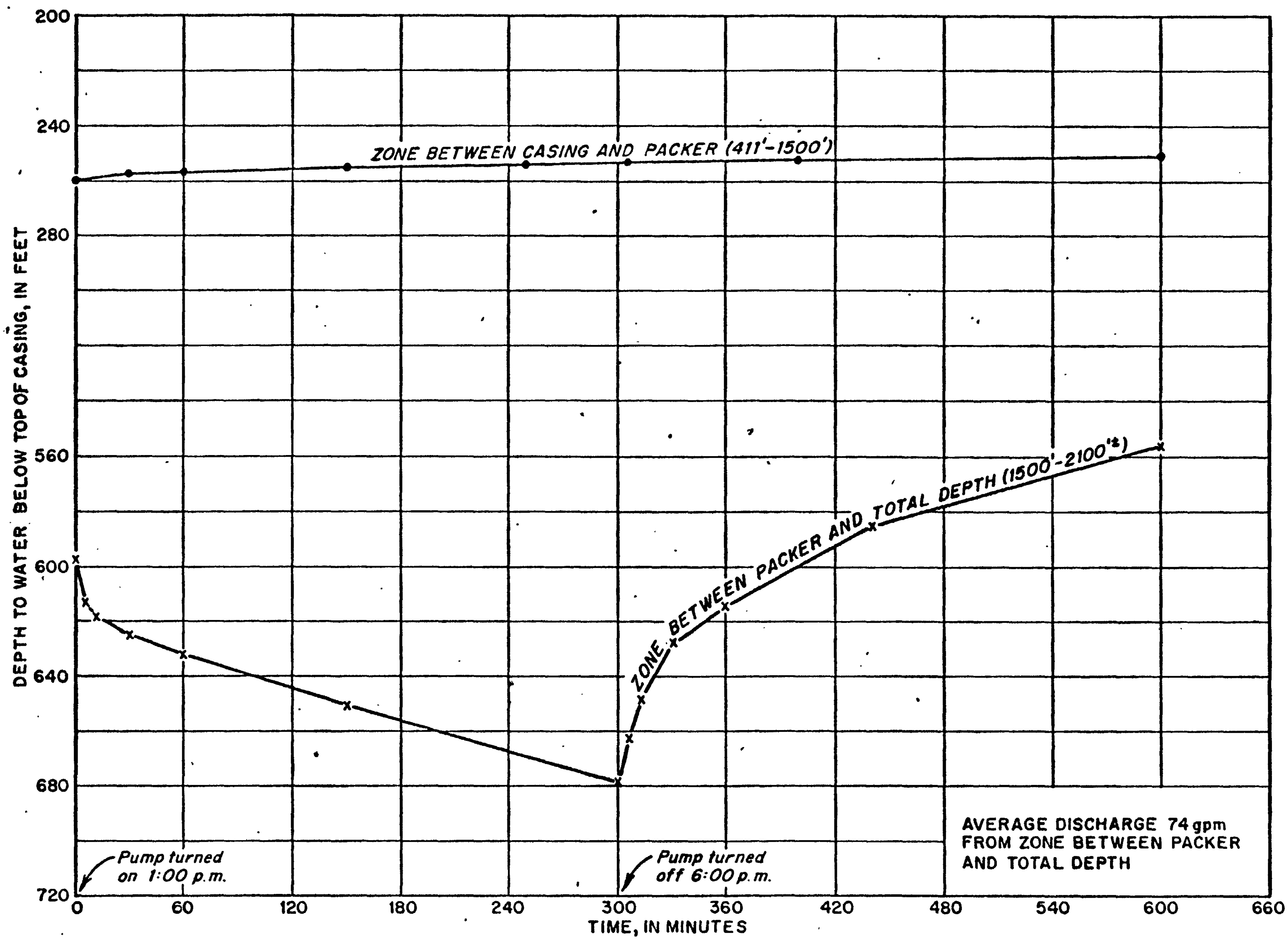

FIGURE 8.-Water-level measurements during test No. 3, U.S.B.M./A.E.C. Colorado core hole No. 2, August 29, 1966.

Test No. 4.--No packers were used. The well was pumped at 93.4 gpm for 250 minutes. Drawdown was measured during pumping and recovery was measured for 120 minutes after pumping ceased (fig. 9). Transmissibility computed from the pumping phase was 3,400 gpd per foot (fig. 10) and that from the recovery phase was 3,600 gpd per foot (fig. 11). The computed transmissibilities are probably affected by different rates of flow between the upper losing zone and the lower gaining zone during both pumping and recovery.

Well discharge, water temperature, and specific conductance are shown below:

Time in minutes since pumping began		Discharge (gpm)	Specific conductance (micromhos per cm)	Temperature (°F)
40		93.4	900	67
100		93.4	900	68
150		93.4	750	69
200		93.4	800	68
250		93.4	950	69
	Average	93.4		

Water was moving from rocks near the top of the uncased section down the hole and out into rocks near the bottom of the hole. The data indicating this are:

1. The head in the upper part of the hole is higher than in the lower part of the hole.

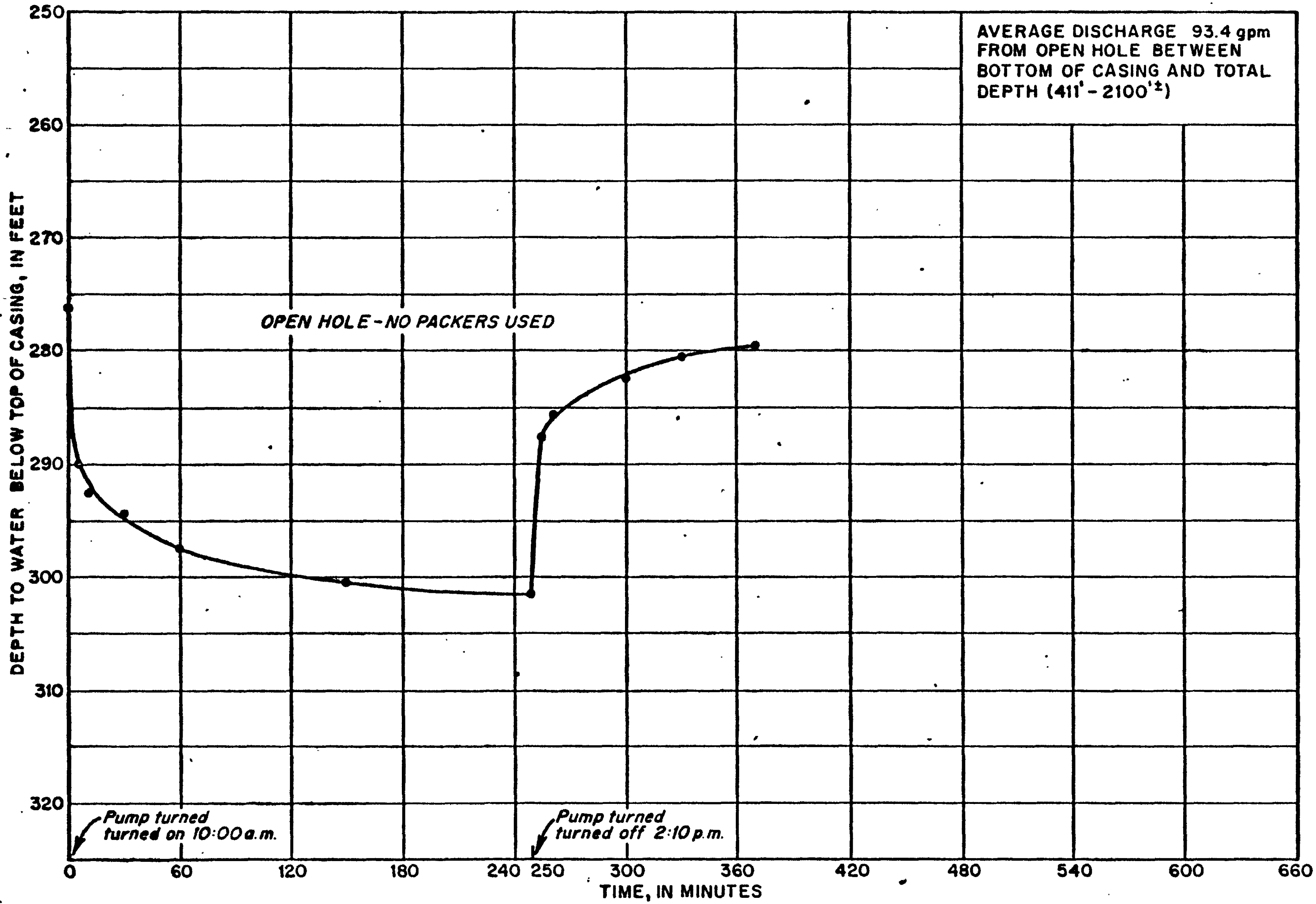

FIGURE 9.-Water-level measurements during test No. 4, U.S.B.M./A.E.C. Colorado core hole No. 2, August 30, 1966.

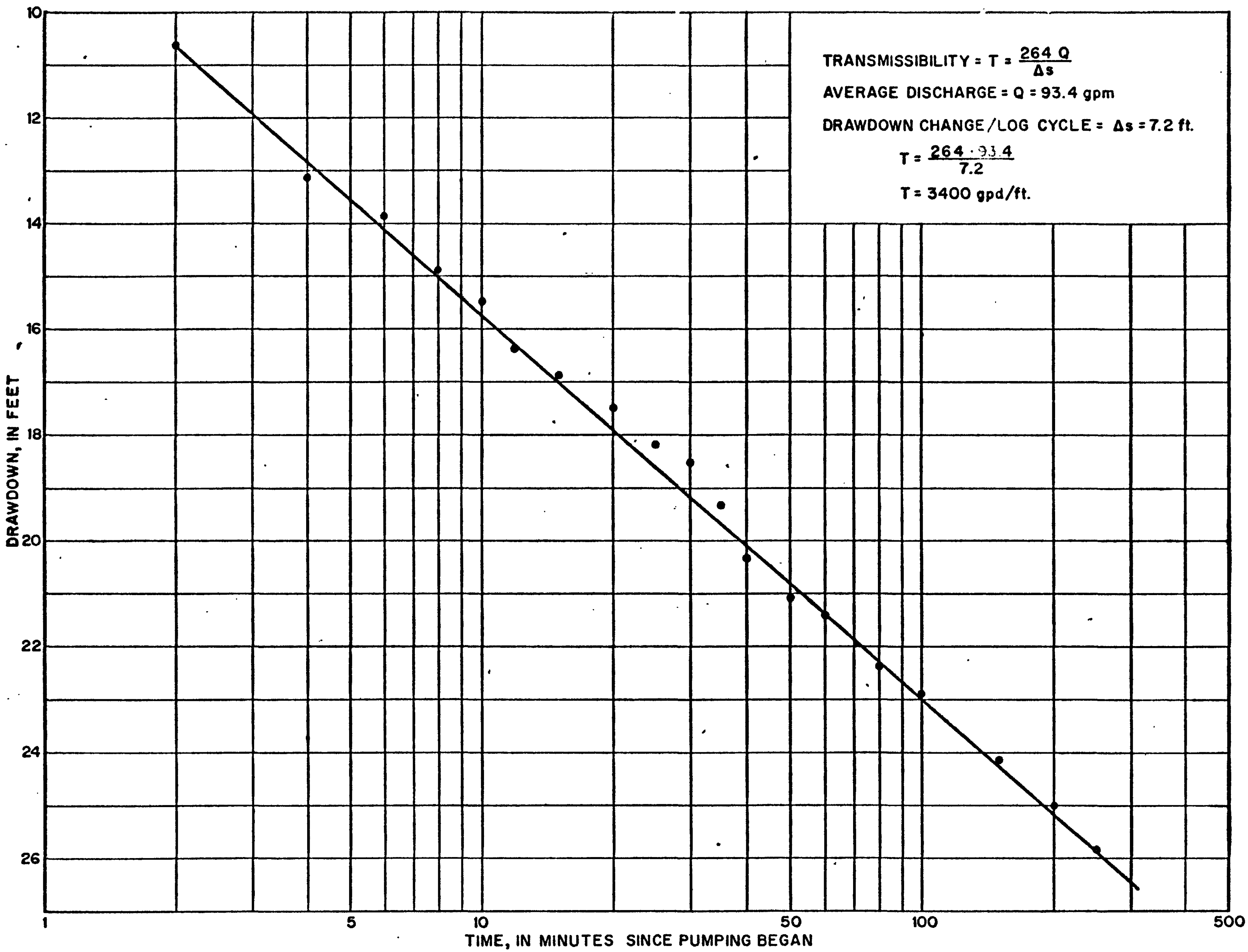

FIGURE 10. - Semilogarithmic graph of drawdown data, pumping open hole between casing and total depth (test No. 4, 411'-2100'±) U.S.B.M./A.E.C. Colorado core hole No. 2, August 30, 1966.

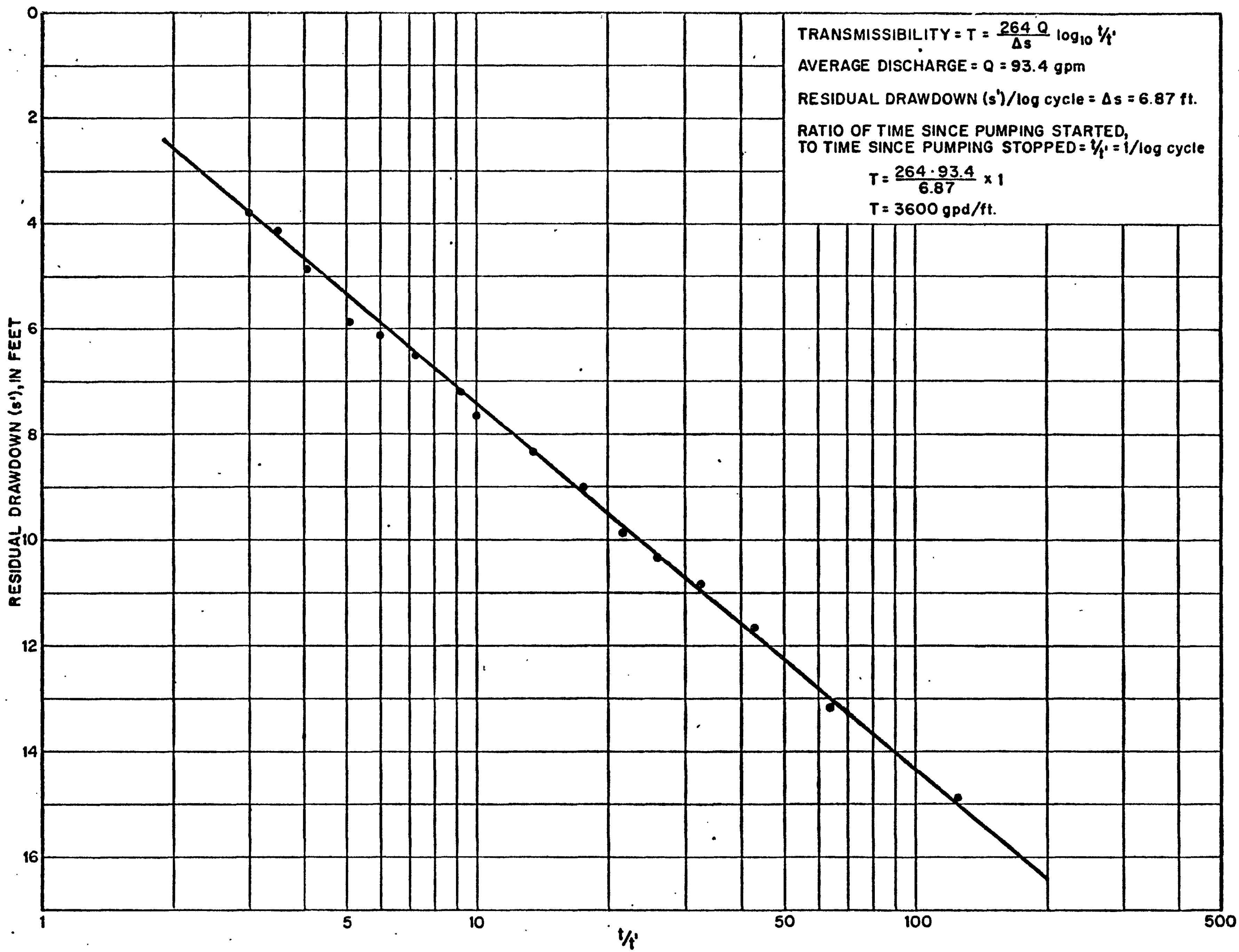

FIGURE 11.- Semilogarithmic graph of recovery data, after pumping open hole between casing and total depth (test No. 4, 411'-2100'±) U.S.B.M. / A.E.C. Colorado core hole No. 2, August 30, 1966.

2. The specific conductance of the water from each test was about the same as that of the water from the upper part of the hole; whereas, during drilling the specific conductance of water from the bottom of the hole was much higher than that of the water from the top part of the hole. Water moved down the hole from the time that drilling was completed until the packer tests were made. The amount of water withdrawn during the test was too small to "retrieve" all the "top" water from the lower part of the hole.

Deep-well current-meter survey

On October 21, 1966, a current-meter survey was made on USBM/AEC Colorado core hole No. 2, using a Deerheardt-Owen spinner flowmeter. The well was not pumped during the survey. Results of the survey (fig. 12) indicate that on October 21, water was entering the hole between depths of about 1,200 to 1,400 feet, moving downward at velocities of as much as 20 feet per minute and leaving the hole between depths of about 1,900 to 2,070 feet. The quantity of water moving down the hole at that time was about 30 gpm.

Quality of water

The chemical analysis of water pumped from the zone between the packers (900-1,200 feet) during test No. 1, is shown in table 8, and the chemical analysis of water pumped from the zone between the packer

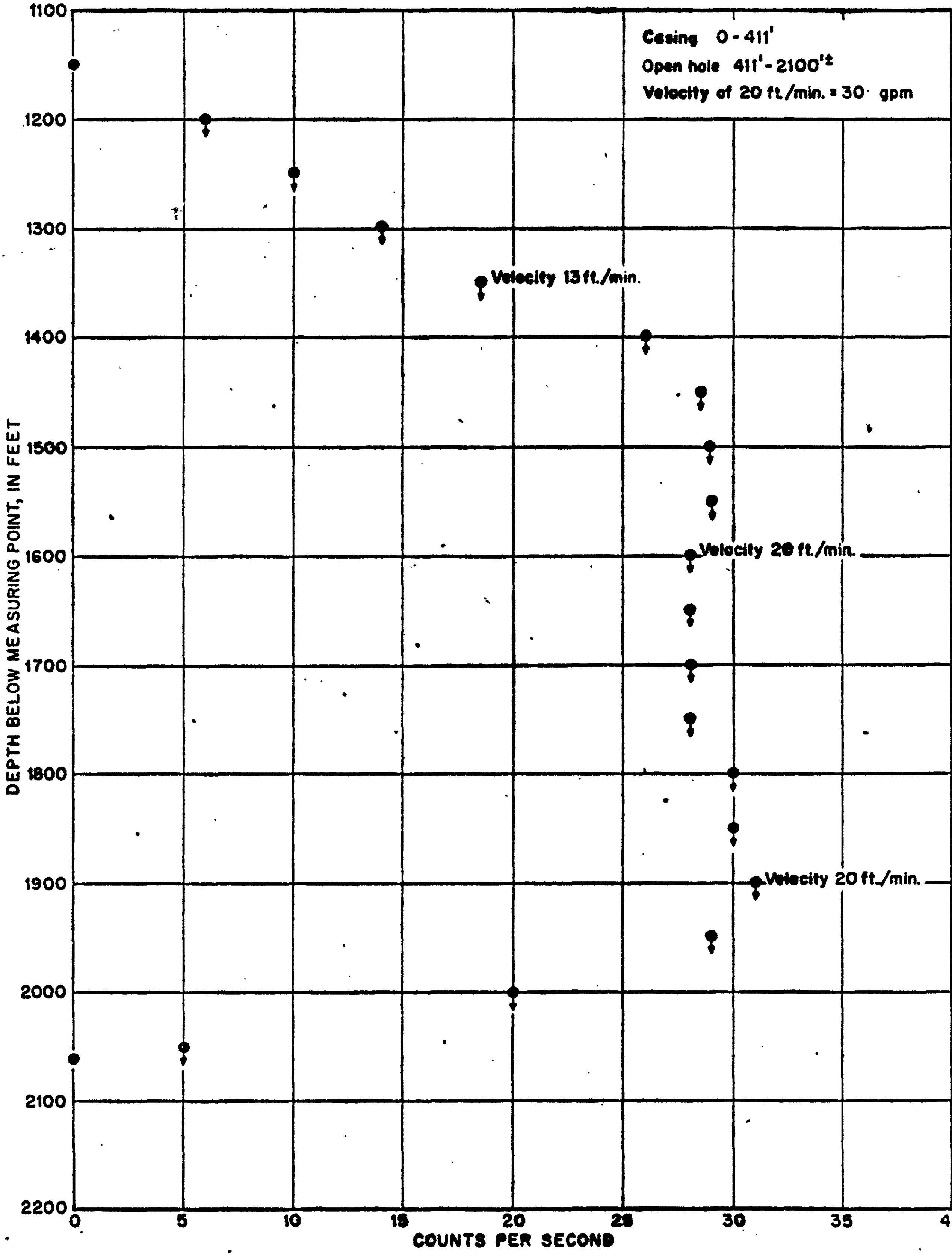

FIGURE 12.- Results of deep-well current meter survey in U.S.B.M./A.E.C Colorado core hole No. 2, October 21,1966.

Table 8 Chemical analysis of ground water pumped from zo e between depths of 900 to 1200 feet.

Lab. No. 32237

U. S. DEPT. OF THE INTERIOR -- GEOLOGICAL SURVEY
Statement of Water Analysis

Source US M/AEC Colorado core hole No. 2
Location 33 miles WSW of Meeker, Colorado, Rio Blanco County
SW ¼ NW ¼ NE ¼ Sec 14 T 1S R 99W Field/Office no.

Date Coll. Aug. 27, 1966 Time
Coll. By F. A. Welder
Field dets: Temp. (°F) 67 pH -
Sp. Cond. (µmhos) 1000 Eh -
Appearance

Test No. 1. Zone between the packers (900-1200 ft)

Well Type Core Use Test hole
Depth (ft.) 2100± Cased to 411
Diam. (in.) 7-5/8" Date drilled June 1966
Water level (ft.) 311
Discharge 94
W. B. F. Evacuation Creek & Parachute Creek Member
Green River Formation
Owner U. S. Bureau of Mines

Chemical components	ppm	epm
Silica (SiO_2)	13.0	
Aluminum (Al)		
Iron (Fe)		
Manganese (Mn)		
Calcium (Ca)	6.0	0.30
Magnesium (Mg)		0.58
Strontium (Sr)		
Sodium (Na)	235.0	10.22
Potassium (K)	0.5	0.01
Cations (epm)	11.11	
Bicarbonate (HCO_3)	494	8.10
Carbonate (CO_3)		
Sulfate (SO_4)	113	2.35
Chloride (Cl)	4.8	0.14
Fluoride (F)	3.3	0.17
Nitrate (NO_3)	0.2	
Phosphate (PO_4)	0.06	
Boron (B)	0.12	
Anions (epm)	10.76	

Physical characteristics and computed values	
Dissolved Solids (ppm)	
Res. on evap. at 180°C	621
Calculated	626
Suspended solids (ppm)	
Hardness as $CaCO_3$ (ppm)	
Total	44
Non-carbonate	
Specific conductance (µmhos at 25°C)	970
pH	8.2
Color	--

Radiochemical data	
Alpha activity (pc/l) as of	
Beta activity (pc/l) as of	
Radium (Ra) (pc/l)	
Uranium (U) (µg/l)	

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GPO 842535

and total depth (1,500-2,100± feet) during test No. 3, is shown in table 9. The analyses show that the water in the two zones is similar; in both samples the principal cation was sodium and the principal anion was bicarbonate. Samples from other zones were taken for analysis, but the results are not yet available.

Table 9 Chemical analysis of ground water pumped from zone between depths of 1500 to 2100 ± feet

Lab. No. 32238

U. S. DEPT. OF THE INTERIOR -- GEOLOGICAL SURVEY
Statement of Water Analysis

Source USBM/AEC Colorado core hole No. 2
Location 33 miles WSW of Meeker, Colorado, Rio Blanco County
SW ¼ NE ¼ NE ¼ Sec 1 T 1S R 99 W Field/Office No.

Date Col. Aug. 2?, 1966 Time
Col. By F. A. Welder
Field data: Temp. (°F) 70 pH -
Sp. Cond. (µmhos) ?20 Eh -
Appearance -
Test No. 3 Zone between packer and total depth (1500-2100 ± feet).

Well Type
Use Test Hole
Depth (ft.) 2100 ±
Cased to 411
Diam. (in.) 7-5/8"
Date drilled June 196?
Water level (ft)
Discharge 74 GPM
W. B. F. Parachute Creek Member, Green River Formation
Owner U. S. Bureau of Mines

Chemical components	ppm	epm
Silica (SiO_2)	13	
Aluminum (Al)		
Iron (Fe)		
Manganese (Mn)		
Calcium (Ca)	6.4	.32
Magnesium (Mg)		.48
Strontium (Sr)		
Sodium (Na)	248.0	10.79
Potassium (K)	0.4	0.01
Cations (epm)		11.60
Bicarbonate (HCO_3)	564.0	9.24
Carbonate (CO_3)	277.0	
Sulfate (SO_4)	97.0	2.02
Chloride (Cl)	3.2	0.09
Fluoride (F)	6.8	0.36
Nitrate (NO_3)	0.3	0.001
Phosphate (PO_4)	0.01	
Boron (B)	0.11	
Anions (epm)		11.711

Physical characteristics and computed values	
Dissolved Solids (ppm)	
Res. on evap. at 180°C	650
Calculated	658
Suspended solids (ppm)	-
Hardness as $CaCO_3$ (ppm)	
Total	40
Non-carbonate	
Specific conductance (µmhos at 25°C)	1040
pH	8.1
Color	

Radiochemical data	
Alpha activity (pc/l) as of	
Beta activity (pc/l) as of	
Radium (Ra) (pc/l)	
Uranium (U) (µg/l)	

Lab. No. Analysts Date Checked

QW-1

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