A Comparison Among Caliper-Log, Gamma-Ray-Log, and Other Diamond-Drill-Hole Data

GEOLOGICAL SURVEY BULLETIN 1052-G

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By C. M. BUNKER *and* H. C. HAMONTRE

EXPERIMENTAL AND THEORETICAL GEOPHYSICS

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A COMPARISON AMONG CALIPER-LOG, GAMMA-RAY-LOG, AND OTHER DIAMOND-DRILL-HOLE DATA

By C. M. Bunker and H. C. Hamontre*

ABSTRACT

To obtain comparative data on the variation in gamma-ray intensity accompanying possible variation in the diameter of small-diameter diamond-drill holes, six drill holes in the Jo Dandy area, Montrose County, Colo., were caliper logged using a well-bore caliper developed by the U. S. Bureau of Mines. The caliper logs show that within radioactive-ore zones the variation in drill-hole diameter is insufficient to cause significant variation in the gamma-ray logging measurement, that with increasing particle size in the ore-bearing sandstone the drill-hole diameter tends to increase slightly, and that with increase in hole diameter the core recovery tends to decrease slightly.

INTRODUCTION

In the investigation of gamma-ray logs, particular emphasis has been placed on the calibration of the logs in terms of the thickness and grade of radioactive ores. One factor in such calibration is variation in drill-hole diameter. Controlled experimental gamma-ray logging measurements have shown that an increase in the diameter of a drill hole might either increase or decrease the measured radiation intensity, depending upon the geometry of a particular measurement. Thus, sufficient variation in the hole diameter where overbreaking, sloughing, or swelling has occurred in the drill hole might lead to erroneous estimation from the gamma-ray log of the thickness and grade of ore. Although few or no data existed on the variation of hole diameter in actual exploratory drilling for carnotite deposits in the Colorado Plateau region before the present study, overbreaking or sloughing of drill-hole walls was suspected to occur in the higher grade ore zones.

The need for caliper logs of drill holes has long been obvious, but the small diameter of the customary diamond-drill holes in the Colorado Plateau region—most are AX and BX size—has heretofore prevented such logging. Recently, a caliper designed to pass through a 2-inch ID pipe was developed by the U. S. Bureau of Mines. By cooperative agreement between the U. S. Bureau of Mines and the

*U. S. Bureau of Mines.

U. S. Geological Survey, six selected drill holes were caliper logged in October 1953. This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

LOCATION

The drill holes (JD-327, JD-329, JD-339, JD-341, A, and B) are part of the Jo Dandy drilling project in Montrose County, Colo, the general area of which is shown on the index map (fig. 66). The first

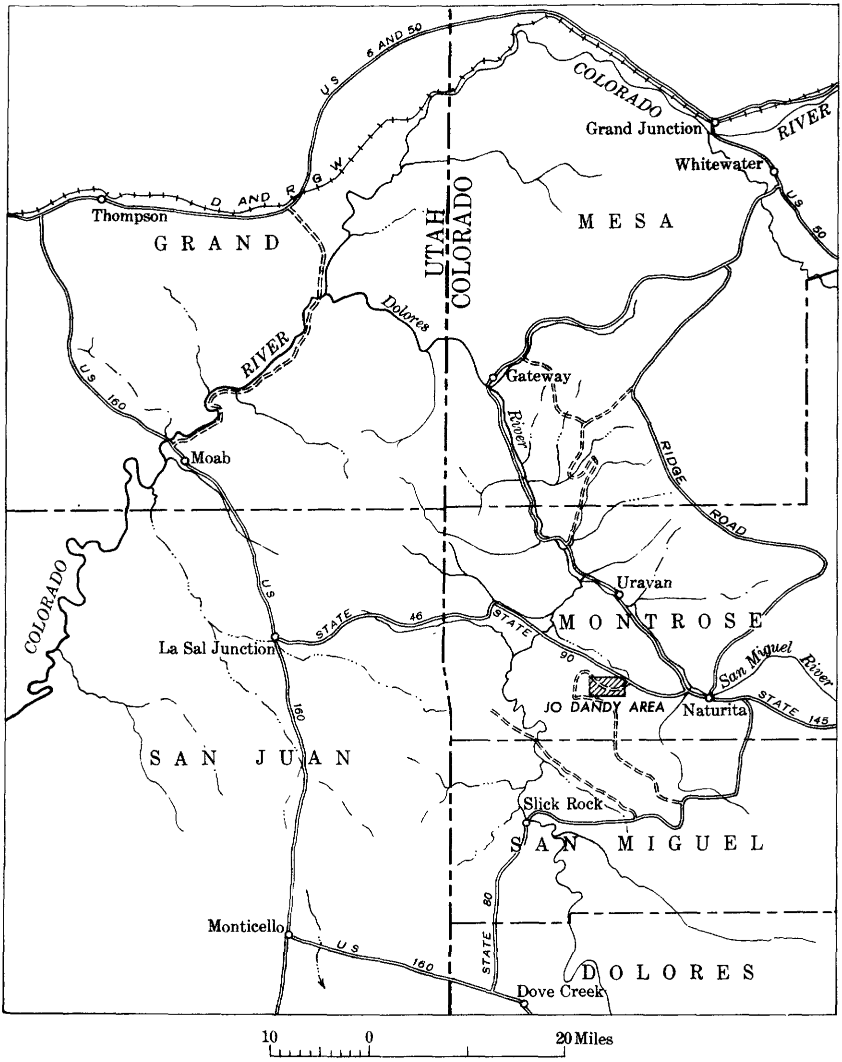

FIGURE 66.—Index map of part of the Colorado Plateau showing the location of the Jo Dandy area, Montrose County, Colo.

four holes were drilled by a contractor for the Geological Survey. Holes A and B were drilled by the Climax Uranium Co., Grand Junction, Colo.

CALIPER LOGGING

EQUIPMENT

The Bureau of Mines well-bore caliper was designed to provide an instrument that could pass through 2-inch tubing. It is suspended from a single-conductor armored electrical cable (Amergraph, type 1–H–0). The instrument differs from other well-bore calipers in that it measures four equispaced radii of the hole with an accuracy of one-fourth inch. The measuring arms can be opened and closed when the instrument is at any depth in the well. The well-bore caliper is 1¾ inches in diameter and approximately 6 feet long. The measuring arms are forced outward simultaneously by an electro-hydraulic system but move independently so that each arm can take any position to follow the shape of the well bore. Each arm is linked mechanically to a variable resistor so that the degree of arc of the arm can be measured with an ammeter at the surface. The ammeter is calibrated to read directly in inches the distance the arm tip is extended from the longitudinal axis of the probe. The position of each of the four arms is determined by using a mechanism to switch current through each resistor. The diameter of the drill hole is then determined by adding the readings from opposite arms.

Figure 67 shows the caliper probe and the auxiliary equipment used in making well-bore measurements. The caliper is lowered into the well on the cable from a reel mounted in a laboratory truck. A 3-kilowatt 110-volt alternating-current generator supplies power for operation of the instrument. Contact between the control panel and the conductor of the cable is made through the hub of the cable reel by a slip-ring contact, giving the operator full control of the probe throughout the depth of the well, allowing him to open and close the measuring arms and observe the reading on the meter in the control panel.

The cable reel is driven by a gasoline engine which is coupled to the reel through a hydraulic drive in order to prevent overloading the cable if the instrument sticks in the hole while it is being withdrawn. A weight indicator shows the tension of the cable at all times. The cable runs through a depth indicator at the surface which indicates the depth of the caliper probe to within one-half foot.

PROCEDURE

The initial step in caliper logging is to turn on the electric current and to allow about 20 minutes for the warmup and stabilization of the electrical components in the circuit. To calibrate the caliper before

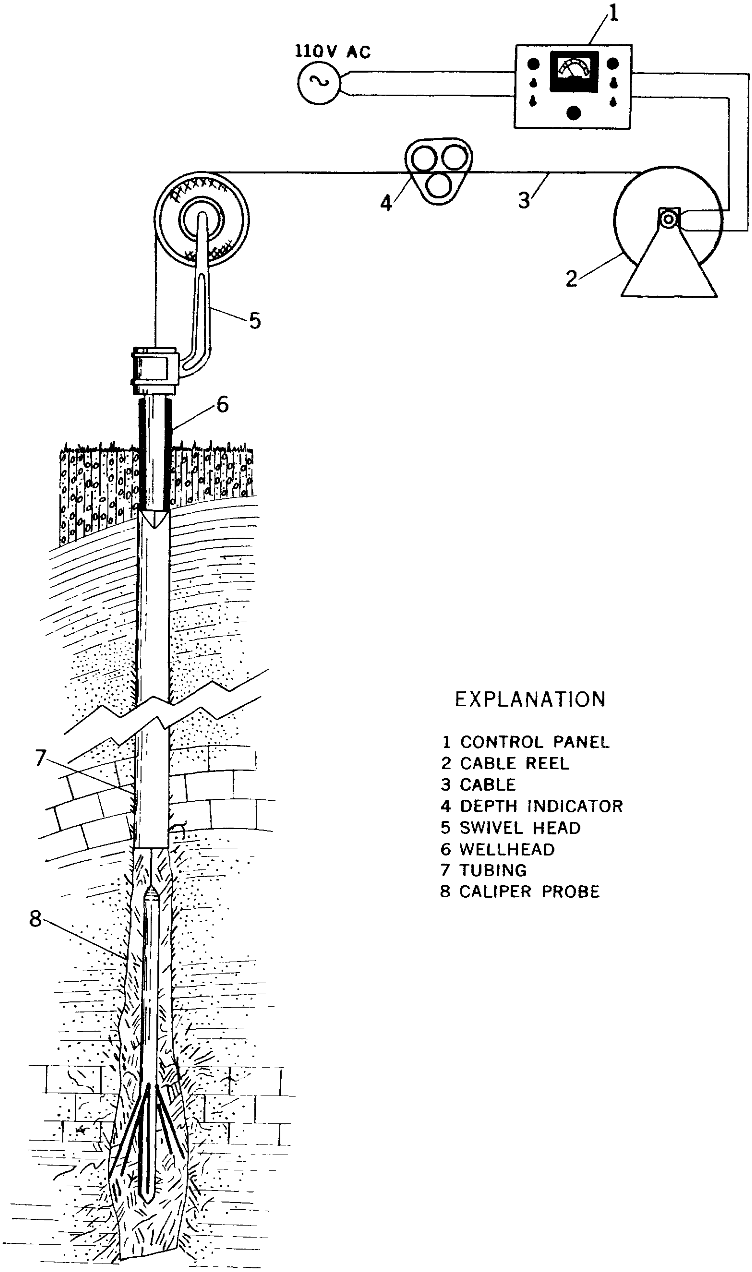

FIGURE 67.—Well-bore caliper in well.

logging, the measuring arms are expanded to the full open position (18 inches) and the measuring circuit is checked with a calibration ring of that diameter. When the measurements are correct at fully open and fully closed positions, the circuit has been stabilized and the instrument is ready for use. The measuring arms are closed, the probe is lowered to the bottom of the hole, and the measuring arms are reopened. Measurements are made at selected points as the well-bore caliper is drawn up. The instrument is suspended at each position at which a reading is made, and measurements are recorded for each of the four measuring arms. Depths at observation points in the hole are recorded, together with the corresponding well-bore measurements. A reading can be made, recorded, and the instrument moved to the next position in approximately 20 seconds when the depth increment is 1 foot or less.

The procedure in calipering the drill holes on the Colorado Plateau was to start approximately 10 feet below the ore body and log at 1-foot increments up to the ore zone, at 6-inch increments through the ore zone, and at 1-foot increments for 10 feet above the ore. Some of the logs show the diameters to be smaller than the diameter of the drill for 3 or 4 feet (for example, JD–339, 681.0–684.0 ft; JD–341, 173.0–175.0 ft). This is believed to have been caused by failure of the measuring arms to penetrate mud on the walls. Penetration could have been achieved by raising and lowering the instrument for a short distance after the arms were opened and before starting to log, but this was not done for fear of dislodging material from the walls and causing the instrument to jam. All holes were gamma-ray logged, then immediately caliper logged in order to determine the hole size when the gamma-ray log was made.

As this caliper probe is a prototype and the only one built before this work, maximum precaution was taken to prevent its loss. Badly caved holes in which there was chance of wedging the probe and losing it were not logged.

RESULTS

The data compiled for the 6 holes include the depth at which the various data were obtained; the average diameter of the hole determined by taking one-half the summation of the 4 radii; percentage core recovery; the percent equivalent U_3O_8 of the pulverized core; the percent chemical U_3O_8 of the pulverized core; the counts per minute derived from the core by a radiometric core scanner; the thickness and percent equivalent U_3O_8 for radioactive zones as determined from the gamma-ray log (Barnaby); and, the rock type and its texture. These are given in table 3.

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COMPARISON OF DIAMETER WITH PERCENTAGE CORE RECOVERY

Analysis of the measurements of drill-hole diameter with the corresponding percentage core recovery shows only a slight tendency for the hole diameter to increase as the percentage of core recovery decreases. Table 1 shows the comparison of the measured drill-hole diameters with the corresponding percentage core recovery. Before the caliper measurements, it had been thought that factors causing low core recovery might also cause a corresponding increase in hole diameter.

TABLE 1.—*Relation between drill-hole diameter and core recovery*

Drill hole	Diameter of bit (in.)	Avg diameter of hole (in.)	Drill-hole diameter (in.) where core recovered [1] (percent) was—							
			7.5	10	20	30	44	46	48	50
JD-327	3.00	3.38								
JD-329	2.32	3.26	3.46	3.35		2.78			3.26	
JD-339	3.00	3.50								
JD-341	3.00	3.59					3.19	2.88		
A	3.00	4.32		4.64	3.69	4.21				
B	2.32	4.45		4.34	4.72	4.11				6.50

Drill hole	Diameter of bit (in.)	Avg diameter of hole (in.)	Drill-hole diameter (in.) where core recovered [1] (percent) was—						
			51	60	72	88	92	99	100
JD-327	3.00	3.38							3.38
JD-329	2.32	3.26			3.02				
JD-339	3.00	3.50					3.62	3.48	3.49
JD-341	3.00	3.59	3.87			3.85			3.48
A	3.00	4.32							
B	2.32	4.45		3.97					

[1] The percentage of core recovered is derived from the ratio of the length of the core recovered to the length of the run.

Causes of core loss include excessive bit pressure and drilling speed which in turn cause the rod to whip, thereby increasing the size of the drill hole by a reaming action. It was the observation of the Bureau of Mines engineer that the high-core-recovery holes JD–327 (NX bit) and JD–339 (NX bit) were drilled with a high drilling speed, a low bit pressure, and only slight visible whipping of the drill stem. Hole numbers JD–329 (BX bit) and JD–341 (NX bit) were drilled with greater pressure and low drilling speed. The drill stems were observed to be whipping to the extent that the core was probably broken and pulverized as it was cut. In addition, JD–329 and B were drilled with a smaller size bit (BX), which is conducive to greater core loss.

COMPARISON OF DRILL-HOLE DIAMETER WITH ROCK TYPE

The rock types penetrated by the six holes are sandstones of various grain size and mudstone. The ore zones are chiefly sandstone with carnotite as an interstitial material. The friability of the sandstone increases with increasing carnotite content. Results of previous drilling projects indicated that core loss through high-grade ore zones is occasionally serious; however, there was no appreciable core loss due to this cause in the six holes described here.

Analysis of the comparison between the measured drill-hole diameter and the corresponding rock type indicates that the drill-hole diameter increases with increasing grain size of the rock (table 2). This might well be expected as the abrasive action is reduced with a reduction in particle size.

TABLE 2.—*Relation between drill-hole diameter and rock type and texture*

Drill hole	Diameter of bit (in.)	Avg diameter of hole (in.)	Sandstone					Mudstone
			Drill-hole diameter (in.) where grain size was—					
			Fine to medium	Fine	Fine to medium fine	Fine to very fine	Very fine	
JD-327	3.00	3.38	----------	3.52	3.41	3.40	----------	3.14
JD-329	2.32	3.26	----------	3.28	----------	----------	----------	2.75
JD-339	3.00	[1] 3.50	3.56	----------	3.52	3.41	3.37	3.24
JD-341	3.00	[1] 3.59	----------	3.81	3.18	----------	----------	3.80
A	3.00	4.32	----------	----------	----------	----------	----------	----------
B	2.32	4.45	----------	----------	----------	----------	----------	----------

[1] Excluding bottom 4 feet, where arms of caliper were not fully extended to drill-hole wall.

COMPARISON OF DRILL-HOLE DIAMETER WITH EQUIVALENT U_3O_8 CONTENT

Analysis of data in table 3 indicates lack of correlation between the measurements of drill-hole diameter and the corresponding U_3O_8 content of the core samples. It is highly probable that there is an increase in hole size with an increase in U_3O_8 content due to the increase in friability, but the instrument error in the caliper and perhaps lack of sufficient data obscure the correlation.

COMPARISON OF CORE RECOVERY WITH EQUIVALENT U_3O_8 CONTENT

Analysis of data on drill-hole diameter and percentage core recovery as shown in table 3 indicates a lack of correlation between the core recovery and equivalent U_3O_8 content. Although significant core loss in thin, high-grade ore zones is suspected to occur because of occasional discrepancies indicating high activity on the gamma-ray log and relatively low equivalent uranium in the recovered ore samples, the present data in table 3 do not include any information on thin, high-grade ore zones. Thus, no data are available on the possible correlation between increasing equivalent uranium content and decreasing core recovery.

CONCLUSIONS

Evaluation of the relationships among data is limited by the accuracy of measurement of the caliper-logging equipment. The use of long measuring arms in small-diameter holes causes the angle through which the measuring arms move to be small, thus utilizing an undesirable part of the characteristic curve of the tubes in the measuring circuit. Use of shorter arms would increase the arc, thereby increasing the accuracy of the measurements from the present tolerance of plus or minus one-fourth inch.

The following generalized conclusions can be drawn:

1. Variation in drill-hole diameter, particularly through uranium-bearing mineralized zones, is relatively small, in general amounting to an increase of less than one-half inch. Such a change in diameter would have little effect on the gamma-ray logging measurement, probably causing a difference of less than 1 percent in the measurement.
2. The diameter of a drill hole tends to increase with increase in particle size.
3. As the diameter of a drill hole increases, the amount of core recovered tends to decrease slightly.

TABLE 3.—*Physical, geologic, and radioactivity data for six drill holes, Jo Dandy area, Colorado*

[Analyses of pulverized core by S. P. Furman, Hollis Bivens, James Wahlberg, U. S. Geological Survey]

Depth (ft)	Average diameter (in.)	Core					Gamma-ray log		Rock	
		Recovered (percent)	U_3O_8 (percent)[1]	Counts per minute[2]	eU_3O_8 (percent)[1]	Thickness of ore zone (ft)	eU_3O_8 (percent)	Thickness of ore zone (ft)	Type	Texture
DRILL HOLE JD-327										
[Drill-bit diameter, NX (3.0 in.); total depth, 744.5 ft]										
696.0	3.75	100							Sandstone	Fine to very fine.
697.0	3.37	100							do	Do.
698.0	3.50	100					<0.010	0.8	do	Do.
699.0	3.12	100							do	Do.
700.0	3.37	100							do	Do.
701.0	3.62	100							do	Do.
702.0	3.37	100			0.006	1.5			do	Fine to medium fine.
703.0	3.50	100			.006		.010	1.7	do	Do.
704.0	3.37	100			.018		.010		do	Do.
705.0	3.25	100			.018	1.6			do	Do.
705.5	3.25	100			.005				do	Do.
706.0	3.25	100			.005	1.6			do	Do.
706.5	3.25	100			.005				do	Do.
707.0	3.37	100			.007				do	Do.
707.5	3.37	100			.007				do	Do.
708.0	3.50	100			.007				do	Do.
708.5	3.50	100		375	.007	3.7			do	Do.
709.0	3.50	100		440	.007				do	Do.
710.0	3.50	100		390	.007				do	Do.
711.0	3.50	100		375	.003	1.7			do	Do.
712.0	3.50	100		530	.012	.6			do	Do.
713.0	3.37	100	0.20	1,500	.15	.6	.11	.8	do	Do.
714.0	3.50	100		480	.018	.6			do	Do.
715.0	3.50	100		410	.005	1.3			do	Do.
716.0	3.87	100							do	Fine.
717.0	3.37	100							do	Do.
718.0	3.50	100							do	Do.
719.0	3.37	100							do	Do.
720.0	3.50	100							do	Do.
721.0	3.50	100							do	Very fine to fine.
722.0	3.50	100							do	Do.
722.5	3.12	100							do	Do.
723.0	3.37	100							do	Do.

See footnotes at end of table, p. 255.

TABLE 3.—*Physical, geologic, and radioactivity data for six drill holes, Jo Dandy area, Colorado*—Continued

[Analyses of pulverized core by S. P. Furman, Hollis Bivens, James Wahlberg, U. S. Geological Survey]

Depth (ft)	Average diameter (in.)	Core					Gamma-ray log		Rock	
		Recovered (percent)	U_3O_8 (percent)[1]	Counts per minute[2]	eU_3O_8 (percent)[1]	Thickness of ore zone (ft)	eU_3O_8 (percent)	Thickness of ore zone (ft)	Type	Texture
DRILL HOLE JD-327—Continued										
723.5	3.50	100	----	----	----	----	----	----	Sandstone	Very fine to fine.
724.0	3.37	100	----	----	----	----	----	----	do	Do.
724.5	3.37	100	----	----	----	----	----	----	do	Do.
725.0	3.37	100	----	----	----	----	----	----	do	Do.
726.0	3.37	100	----	----	----	----	----	----	do	Do.
727.0	3.37	100	----	----	----	----	----	----	do	Do.
728.0	3.37	100	----	----	----	----	0.034	1.0	do	Do.
729.0	3.12	100	----	----	----	----	----	----	Mudstone	
730.0	3.25	100	----	----	----	----	----	----	do	
731.0	3.25	100	----	----	----	----	----	----	do	
732.0	3.12	100	----	----	----	----	----	----	do	
733.0	3.12	100	----	----	----	----	----	----	do	
734.0	3.00	100	----	----	----	----	----	----	do	
DRILL HOLE JD-329 [Drill-bit diameter, BX (2.32 in.); total depth, 550.0 ft]										
407.0	3.50	7.5	----	----	----	----	----	----	Sandstone	Fine.
408.0	3.50	7.5	----	----	----	----	----	----	do	Do.
409.0	3.50	7.5	----	----	----	----	----	----	do	Do.
410.0	3.37	7.5	----	----	----	----	----	----	do	Do.
411.0	3.50	7.5	----	----	----	----	----	----	do	Do.
412.0	3.37	7.5	----	----	----	----	----	----	do	Do.
413.0	3.50	7.5	----	----	----	----	----	----	do	Do.
414.0	3.50	7.5	----	----	----	----	----	----	do	Do.
415.0	3.25	10	----	----	----	----	----	----	do	Do.
416.0	3.50	10	----	----	----	----	----	----	do	Do.
416.5	3.50	10	----	----	----	----	----	----	do	Do.
417.0	3.25	10	----	----	----	----	----	----	do	Do.
417.5	3.25	10	----	----	----	----	----	----	do	Do.
418.0	3.25	10	----	----	----	----	----	----	do	Do.
418.5	3.37	10	----	----	----	----	----	----	do	Do.
419.0	3.25	10	----	----	----	----	----	----	do	Do.
419.5	3.50	10	----	----	----	----	----	----	do	Do.

420.0	3.37	48					0.011	0.6	do	Do.
420.5	3.37	48							do	Do.
421.0	3.37	48							do	Do.
421.5	3.25	48							do	Do.
422.0	3.12	48					<.010	.8	do	Do.
422.5	3.25	48					<.010		do	Do.
423.0	3.25	48							do	Do.
424.0	3.12	48							do	Do.
425.0	3.12	72							do	Do.
426.0	3.00	72							do	Do.
427.0	3.00	72							do	Do.
428.0	3.00	72							do	Do.
429.0	3.00	72							do	Do.
430.0	2.87	30							do	Do.
431.0	2.87	30							Mudstone	
432.5	2.62	30							do	

DRILL HOLE JD-339

[Drill-bit diameter, NX (3.0 in.); total depth, 732.2 ft]

650.0	3.50	92							Sandstone	Fine to medium.
651.0	3.50	92							do	Do.
652.0	3.62	92							do	Do.
653.0	3.62	92							do	Do.
654.0	3.87	92							do	Do.
655.0	3.62	100							do	Do.
656.0	3.62	100							do	Do.
657.0	3.62	100							do	Do.
658.0	3.75	100							do	Do.
659.0	3.75	100							do	Do.
660.0	3.62	100							do	Do.
661.0	3.50	100							do	Do.
662.0	3.62	100							do	Do.
663.0	3.62	100							do	Do.
663.0	3.50	100							do	Do.
664.0		100							do	Do.
664.5	3.37	99							do	Do.
665.0	3.62	99							do	Do.
665.5	3.50	99							do	Do.
666.0	3.50	99							do	Do.
666.5	3.50	99							do	Do.
667.0	3.50	99							do	Do.
667.5	3.50	99							do	Do.
668.0	3.50	99							do	Do.
668.5	3.50	99							do	Do.
669.0	3.50	99							do	Do.
669.5	3.50	99							do	Do.
670.0	3.50	99							do	Do.
670.5	3.50	99							do	Do.

See footnotes at end of table, p. 255.

TABLE 3.—*Physical, geologic, and radioactivity data for six drill holes, Jo Dandy area, Colorado*—Continued

[Analyses of pulverized core by S. P. Furman, Hollis Bivens, James Wahlberg, U. S. Geological Survey]

Depth (ft)	Average diameter (in.)	Core					Gamma-ray log		Rock	
		Recovered (percent)	U_3O_8 (percent)[1]	Counts per minute[2]	eU_3O_8 (percent)[1]	Thickness of ore zone (ft)	eU_3O_8 (percent)	Thickness of ore zone (ft)	Type	Texture
DRILL HOLE JD-339—Continued										
671.0	3.37	99	0.26	1,229	0.21	0.3			Sandstone	Fine.
671.5	3.50	99	.98	6,000	.73	.9	1.30	1.6	do	Do.
672.0	3.37	99	2.82	6,000	1.8	.3	1.30		do	Do.
672.5	3.62	99	.91	7,000	.77	.5	1.30		do	Fine to medium fine.
673.0	3.62	99	.065	800	.060	} .4	{		do	Do.
673.5	3.50	99							do	Do.
674.0	3.37	99	.045	860	.049	.3			do	Medium fine.
674.5	3.25	99							Mudstone	
675.0	3.50	100							do	
676.0	3.50	100		630			.012	1.3	do	
677.0	3.25	100		575			.012		do	
678.0	3.00	100							do	
679.0	3.00	100							do	
680.0	3.37	100							Sandstone	Very fine.
681.0	2.75	100							do	Do.
682.0	2.87	100							do	Do.
683.0	2.50	100							do	Do.
684.0	2.50	100							do	Do.
DRILL HOLE JD-341 [Drill-bit diameter, NX (3.0 in.); total depth, 195.3 ft]										
140.0	3.87	88							Mudstone	
141.0	3.87	88							do	
142.0	4.00	88							do	
143.0	3.75	88							do	
144.0	3.75	88							do	
145.0	3.62	51							Sandstone	Fine.
146.0	3.62	51							do	Do.
147.0	3.75	51							do	Do.
148.0	3.75	51							do	Do.
149.0	3.75	51							do	Do.
150.0	3.75	51							do	Do.

151.0	3.75	51							do	Do.
152.0	4.12	51							do	Do.
153.0		51							do	Do.
153.5	3.87	51							do	Do.
154.0	4.12	51							do	Do.
154.5	4.25	51							Mudstone	
155.0	4.12	51							do	
155.5	3.62	100							do	
156.0	3.75	100							do	
156.5	3.62	100							do	
157.0	3.62	100					<0.010	1.8	od	
158.0	3.37	100					< .010		do	
159.0	3.37	100							do	
160.0	3.00	100							Sandstone	Fine to medium fine.
161.0	3.12	44							do	Do.
162.0	3.12	44							do	Do.
163.0	3.00	44							do	Do.
164.0	3.12	44							do	Do.
165.0	3.12	44							do	Do.
166.0	3.25	44							do	Do.
168.0	3.37	44							do	Do.
169.0	3.37	44							do	Do.
170.0	3.25	44							do	Do.
171.0	3.25	46							do	Do.
172.0	3.00	46							do	Do.
173.0	2.75	46							do	Do.
174.0	2.87	46							do	Do.
175.0	2.50	46							do	Do.

DRILL HOLE A

[Drill-bit diameter, NX (3.0 in.)]

253.0	4.25	30							Mudstone	
254.0	4.12	30							do	
255.0	4.25	30					<0.010	1.4	Sandstone	Very fine.
256.0	4.25	10							do	Do.
257.0	4.12	10							do	Fine to medium fine.
258.0	4.62	10							do	Do.
259.0	9.12	10					<.010	3.0	do	Do.
259.5	6.62	10					<.010		do	Do.
260.0	5.50	10					<.010		do	Do.
260.5	4.25	10					<.010		do	Do.
261.0	4.12	10					<.010		do	Do.
262.0	4.12	10					.03	.8	do	Do.
262.5	4.50	10					.03		do	Do.
263.0	3.87	10					<.010	3.0	do	Do.
263.5	3.87	10					<.010		do	Do.
264.0	3.87	10					<.010		do	Do.
264.5	3.75	10					<.010		do	Do.

See footnotes at end of table, p. 255.

TABLE 3.—*Physical, geologic, and radioactivity data for six drill holes, Jo Dandy area, Colorado*—Continued

[Analyses of pulverized core by S. P. Furman, Hollis Bivens, James Wahlberg, U. S. Geological Survey]

Depth (ft)	Average diameter (in.)	Core					Gamma-ray log		Rock	
		Recovered (percent)	U_3O_8 (percent)[1]	Counts per minute[2]	eU_3O_8 (percent)[1]	Thickness of ore zone (ft)	eU_3O_8 (percent)	Thickness of ore zone (ft)	Type	Texture
DRILL HOLE A—Continued										
265.0	3.75	10					<0.010		Sandstone	Fine to medium fine.
266.0	3.62	20					<0.010		do	Do.
267.0	4.00	20							do	Do.
268.0	3.75	20							do	Do.
269.0	3.62	20							do	Do.
270.0	3.62	20							do	Do.
271.0	3.62	20							do	Do.
272.0	3.75	20							do	Do.
273.0	3.50	20							do	Do.
DRILL HOLE B [Drill-bit diameter, BX (2.32 in.); total depth, 375.0 ft]										
260.0	4.25	50							Mudstone	
261.0	4.12	50							do	
262.0	6.87	50							do	
263.0	7.62	50							Sandstone	Very fine.
264.0	11.00	50							do	Do.
265.0	5.12	50							do	Do.
266.0	4.87	20							do	Do.
267.0	4.87	20							do	Do.
268.0	4.62	20							do	Do.
269.0	4.50	20							do	Do.
270.0	4.50	20							do	Do.
271.0	4.12	20							Mudstone	
272.0	4.87	20					<0.010	1.2	do	
273.0	4.62	20							do	
274.0	4.87	20							do	
275.0	5.37	20							do	
276.0	5.25	10							do	
277.0	5.12	10							do	
278.0	4.25	10							do	
278.5	4.25	10							do	
279.0	4.25	10							do	

279.5	4.00	10	---	---	---	---	---	---	do	
280.0	4.25	10	---	---	---	---	---	---	do	
280.5	4.12	10	---	---	---	---	.019	1.2	do	
281.0	4.12	10	---	---	---	---	---	---	do	
281.5	4.25	10	---	---	---	---	---	---	do	
282.0	4.25	10	---	---	---	---	---	---	do	
282.5	4.25	10	---	---	---	---	---	---	do	
283.0	4.25	10	---	---	---	---	<.010	1.1	do	
283.5	4.25	10	---	---	---	---	---	---	Sandstone	Fine.
284.0	4.25	10	---	---	---	---	---	---	do	Do.
285.0	4.25	10	---	---	---	---	---	---	do	Do.
286.0	4.25	30	---	---	---	---	---	---	do	Do.
287.0	4.12	30	---	---	---	---	---	---	do	Do.
288.0	4.12	30	---	---	---	---	---	---	do	Do.
289.0	4.12	30	---	---	---	---	---	---	do	Do.
290.0	4.25	30	---	---	---	---	---	---	do	Do.
291.0	4.25	30	---	---	---	---	---	---	do	Do.
292.0	4.12	30	---	---	---	---	---	---	do	Do.
293.0	4.12	30	---	---	---	---	---	---	do	Do.
294.0	4.12	30	---	---	---	---	---	---	do	Do.
295.0	4.25	30	---	---	---	---	<.010	.9	do	Do.
296.0	4.37	30	---	---	---	---	---	---	do	Do.
297.0	4.37	30	---	---	---	---	---	---	do	Do.
298.0	4.62	30	---	---	---	---	---	---	do	Do.
299.0	4.50	30	---	---	---	---	---	---	do	Do.
300.0	4.62	30	---	---	---	---	---	---	do	Do.
301.0	4.62	30	---	---	---	---	<.010	1.9	do	Do.
302.0	4.12	30	---	---	---	---	<.010	---	do	Do.
303.0	4.12	30	---	---	---	---	---	---	do	Do.
304.0	4.00	30	---	---	---	---	---	---	do	Do.
305.0	3.75	30	---	---	---	---	---	---	do	Do.
306.0	3.50	30	---	---	---	---	---	---	do	Do.
307.0	3.62	30	---	---	---	---	---	---	do	Do.
308.0	3.87	30	---	---	---	---	.010	.9	do	Do.
308.5	3.87	30	---	---	---	---	---	---	do	Do.
309.0	4.00	30	---	---	---	---	---	---	do	Do.
309.5	4.12	30	---	---	---	---	---	---	do	Do.
310.0	4.12	30	---	---	---	---	.016	1.3	do	Do.
311.0	4.00	30	---	---	---	---	---	---	do	Do.
312.0	4.12	30	---	---	---	---	---	---	do	Do.
313.0	3.37	30	---	---	---	---	---	---	do	Do.
314.0	3.87	30	---	---	---	---	<.010	1.4	do	Do.
315.0	4.00	30	---	---	---	---	<.010	---	do	Do.
316.0	4.12	60	---	---	---	---	---	---	Mudstone	
317.0	4.12	60	---	---	---	---	---	---	do	
318.0	4.00	60	---	---	---	---	---	---	do	
319.0	3.87	60	---	---	---	---	---	---	do	
320.0	3.75	60	---	---	---	---	---	---	do	

[1] In pulverized core.
[2] Measured with radiometric core scanner.

NOTE: Leaders indicate that no data are available or that zone is essentially nonradioactive.