Physical and Associated Properties of Uranium-bearing Rock in Five Drill Holes in Karnes County, Texas

by

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

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ILLUSTRATIONS

INTRODUCTION

Five core holes were drilled in the Karnes uranium area, about 9 miles southwest of Falls City and 14 miles west-northwest of Karnes City, Karnes County, Texas, in November and December, 1956, as part of a geophysical and geological study made of the area before the ore was mined. Oil-base mud was used in drilling to prevent contamination of the fluids in the cores; cores were sealed at the hole site in plastic tubes, and both cores and bore-hole properties were studied. The physical and associated properties of the cores of three of the more extensively cored holes were determined. These properties include porosity, permeability, amount of natural-state water, soil gas, capillary water, soluble salt content, and pH and chlorinity of the extracted salt solution. Electrical logs showing resistivity and spontaneous potential, and gamma-ray logs were made of each hole. Cores that showed anomalous radioactivity were analyzed for uranium. Physical and chemical properties were integrated and related to the lithology of the stratigraphic zones as recognized in the area at that time.

ACKNOWLEDGMENTS

Core drilling was done by the Walters Drilling Company of Dallas, Texas. Drill-hole gamma-ray logs were recorded by Carl Bunker, of the U.S. Geological Survey. Drill-hole electrical logs were recorded by the Schlumberger Well Surveying Corporation. Radioactivity scanning of the core while it was sealed in the tubes was done by Dow Hough, formerly of the Geological Survey. Chemical determinations for uranium were made by Ivan Barlow, J. W. Budinsky, B. A. McCall, and A. H. Truesdell, of the Geological Survey. Core analysis was performed by T. E. Sterner, R. B. Lowe, and W. M. Smith, under the direction of W. T. Wertman, of the U.S. Bureau of Mines, Morgantown Petroleum Research Laboratory, Morgantown, West Virginia. A report on the particle-size distribution of selected samples was furnished by A. I. Johnson, of the Hydrologic Laboratory of the U.S. Geological Survey in Denver, Colorado.

Peter Popenoe, of the Geological Survey, examined the core samples under a binocular microscope and made the lithologic logs of the five holes. Mrs. Beth O. Davis, also of the Survey, arranged the data and logs for illustrating the manuscript and drafted the figures.

STRATIGRAPHY

The cores described in this report were taken from rocks in the vicinity of the uranium mines in the Deweesville area, Karnes County, Texas. The cores represent chiefly the McElroy and Whitsett Formations of the Jackson Group (upper Eocene). The Catahoula Tuff (Miocene) that overlies unconformably the upper part of the Whitsett is represented only by 5 feet of its basal part at the top of hole K5. The McElroy and Whitsett have been divided by Eargle (1959) into the following members.

Formation	Member
Whitsett	Fashing Clay Member
	Dubose Member (including the Tordilla sandstone bed)
	Stones Switch Sandstone Member
McElroy	Conquista Clay Member
	Dilworth Sandstone Member
	Manning Clay Member

Mining, extensive drilling, and further stratigraphic research and mapping undertaken in the area since this classification was established have shown that some changes in classification are necessary, but the changes will not be considered here, and the established nomenclature will be followed.

Figure 1 shows the correlation of the beds penetrated by three (K2, K3, K5) of the five core-drilled holes. Electrical and gamma-ray logs are also shown.

McElroy Formation

The Manning Clay Member of the McElroy Formation consists of pale-yellowish-brown to pale-olive bentonitic clay, fine-grained sand and sandstone, and tuff. Only the uppermost 70 feet of a possible 400-foot thickness of this member was drilled in hole K2, and the member was not reached in the other holes. A thin, lignitic tuff that is an excellent marker bed was drilled from 201 to 205 feet below the ground surface. A firm, calcareous sandstone was encountered from 243 to 244 feet, where the hole was bottomed.

The Dilworth Sandstone Member consists of grayish green to medium gray, very fine to fine grained sandstone, carbonaceous shale, and shaly siltstone. Some fossil-plant material was found in the upper part of the unit, and a petroliferous fetid (hydrogen sulfide?) odor was encountered; some fossil mollusks were found in the middle of the unit. Outcrops of this unit show abundant borings of the brackish-water *Ophiomorpha major*. Only the hole K2 penetrated this unit completely; the thickness was determined to be 75 feet.

The Conquista Clay Member consists of gray to green to brown carbonaceous, generally laminated bentonitic clay and minor percentages of very fine grained sand. Fossil plants are abundant in much of this part of the core. Mollusc shells, including an especially significant gastropod *Mesalia* sp. were found from 16 to 30 feet below the top of the core in a sandstone that is an excellent regional stratigraphic-marker bed on the surface. A brown, fissile, lignitic tuff that had a strong fetid (sulfide?) odor was encountered in hole K1 at 213 to 216 feet and in hole K3 at 231 to 237 feet. The thickness of the unit averages 58 feet in the core holes.

Whitsett Formation

The Stones Switch Sandstone Member is a light-gray to light-green fine to very fine grained sand. The middle part of the unit is silty and clayey. Small amounts of carbonaceous material generally are present; also some pyrite and some limonite staining. The thickness of the unit averages about 55 feet.

The Dubose Member consists of light- to dark-gray or greenish-gray sands, silts, and clays, and at least three beds of brown lignitic tuff or lignite. Although most of the section contains some plant matter, the three lignitic beds were found in all holes and are good stratigraphic markers. Pelecypod shells were found near the base of the unit in hole K3.

The Tordilla sandstone bed is at the top of the Dubose in holes K3 and K5. This is a very fine grained gray sand about 35 feet thick. The thickness of the Dubose unit below the Tordilla sandstone bed averages about 82 feet; about 29 feet of the Tordilla sandstone bed was drilled in hole K5.

The Fashing Clay Member, at the top of the Whitsett, consists of olive-green clay, locally fossiliferous, white fine-grained tuff, brown to gray tuffaceous silt, and about 3 feet of lignite and lignitic tuff at its base. The unit is about 80 feet thick in hole K5. The Fashing is overlapped by the Catahoula in the Deweesville area, but to the southwest, where there is no overlap, there is an additional 100 feet of tuffaceous clay at the top of the member.

Catahoula Tuff

The Catahoula Tuff overlies unconformably the Fashing Clay Member of the Whitsett Formation in this area. It consists of pale-brown or buff calcareous tuff with a basal conglomerate of tuff balls, opalized wood, and some chert gravel and coarse sand. It is only about 5 feet thick at the top of hole K5, but down the dip has been found to be about 500 feet thick in wells drilled for oil.

URANIUM MINERALS

Uranium minerals were not found by inspection of core with a hand lens, nor were any identifiable by microscopic examination of core from ore zones at drill holes K1 and K3 (A. H. Truesdell, 1958, written communication). However, Truesdell found that all radioactive material from the ore zones at these drill holes was recoverable as bromoform float. He noted that the only uranium minerals lighter than bromoform are fluorescent (U+6) carbonates, but a check by means of ultraviolet light gave no indication of fluorescence. It is possible that uranium is sorbed by clay minerals, but the uranium-bearing sandstones contain minimum amounts of clay.

URANIUM CONTENT

Uranium and equivalent uranium (oxide) content shown by cores, cuttings, and gamma-ray drill-hole logs for drill holes K1, K2, K3, and K5 are as follows[1/]:

Drill Hole	K1	K2	K3	K5
Altitude, feet	469	414	460	495
Tordilla sandstone bed		Absent		
Radioactive zone, depth, feet	11-12		25-28	95-120
eU_3O_8 (and eU) percent				
Core			0.005-0.018	0.004-0.012 (cuttings)
Drill hole	<0.01		.027- .072	.010- .15
U, percent, core			.002- .011	.004- .011 (cuttings)
Stones Switch Sandstone				Barren
Upper radioactive zone, depth, feet	120-123	Absent or above 16'	143-146	
eU_3O_8 (and eU) percent				
Core	0.006-0.032		0.014-0.093	
Drill hole	<.005- .034		.018- .22	
U, percent, core			.073[2/]	
Lower radioactive zone, depth, feet	157-162	26-29	158-163	
eU_3O_8 (and eU) percent				
Core	0.014-0.11	0.032-0.52	0.006-0.01	
Drill hole	.016- .12	.045- .68	.015	
U, percent, core	.086[3/]	.022- .068		

1/ For this tabulation, radioactivity in counts per minute (shown on figures 3, 4, 5, and 6) has been converted to eU_3O_8 percent.

2/ eU of sample split, 0.073 percent

3/ eU of sample split, 0.079 percent

This tabulation shows that uranium about equals equivalent uranium at depths below 100 feet and apparently at depths from 25 to 28 feet at drill hole K3. At drill hole K2 at depths from 26 to 29 equivalent uranium exceeds uranium by a factor of as much as 10. Uranium in deeper deposits seems to be only slightly oxidized, but in some shallow deposits, as at drill hole K2, it apparently is considerably oxidized. In a pit near drill hole K2 the ore is highly oxidized and in radioactive disequilibrium (MacKallor and others, 1962). Faint, intermittent radioactivity extends to the base of the Stones Switch Sandstone, which at drill holes K1 and K3 is respectively at 171 and 187 feet.

POROSITY AND PERMEABILITY

The uranium-bearing sandstone is soft and unconsolidated and apparently the most permeable and porous of all sandstone that was core-drilled. Specimens of uranium-bearing sandstone usually disintegrated during preparation or testing for porosity and permeability, but 28 samples of unconsolidated barren sandstone from various formational units showed mean porosity as 39 percent and logarithmic mean permeability as about 300 millidarcys. A comparison of grain-size properties and porosity and permeability of a few uranium-bearing and barren samples suggests that mean porosity of uranium-bearing sandstone may exceed 39 percent and logarithmic mean permeability may exceed 300 millidarcys, as follows.

	Soft unconsolidated sandstone	
	Uranium-bearing (4 samples)	Barren (4 samples)
Median grain diameter, mm		
Mean	0.15	0.09
Range	.072- .262	.063- .110
Clay (particles <0.004 mm diam.), percent		
Mean	6	11
Range	2 - 11	4 - 17
Sorting, Trask coefficient		
Mean	1.29	1.70
Range	1.22 - 1.48	1.39 - 2.38
Porosity, percent		
Mean	(not available)	46
Range		41 - 52
Permeability, millidarcys		
Mean, logarithmic	(not available)	303
Range		95 - 854

Larger grain size, less clay content, and better sorting for the uranium-bearing samples indicate greater porosity and permeability. Two of the uranium-bearing samples show the excellent sorting of beach sand as indicated by low sorting coefficients of 1.22 (Krumbein and Pettijohn 1938, p. 232).

URANIUM, SATURATION, AND RESISTIVITY

For the purposes of this report uranium ore is defined as a concentration of uranium of about 0.1 percent eU_3O_8 (or eU) or more that occurs in an interval 1 foot thick or more. Ore at drill holes K1, K2, and K3 occurs near the base of a partially unsaturated zone that usually underlies saturated sandstone. Unsaturation at the top of a uranium-bearing zone grades downward into saturation at the bottom. Uranium does not extend below the level of saturation, but characteristically a shadow zone of radioactivity extends into saturation. For convenience, partially unsaturated zones are designated as saturation zones. Saturation zones at all drill holes are defined by electrical log resistivity zones delimited at inflection depths of spontaneous potential curves.

These relations are illustrated at drill hole K3, as indicated in figure 2. Ore is in the lower part of a resistivity zone that peaks at 19 ohm-meters. The base of the ore is at 144.4 feet. Effectively complete saturation as 97 percent is reached at 145.6 feet, where the core contains uranium as 0.014 percent eU_3O_8.

Saturated sandstone that lies above the resistivity zone that peaks at 19 ohm-meters is soft and fine grained and shalier at the base. Values are spread considerably on each side of 100 percent saturation, probably because of experimental and sampling error. Exceptionally high saturation values, which reach 219.7 percent at 139.9 feet, apparently are due to a physical decrease in porosity occasioned during extraction of fluid contents of the porosity specimens upon which saturation values are based. The three saturation values that apparently exceed 140 percent actually may be less than 100 percent, as they are indicated as lying at the top of the 19 ohm-meter resistivity zone.

There is no evidence that a shale or clay body separates the mentioned saturated sandstone from the underlying partially unsaturated permeable sandstone, where uranium as 0.093 percent eU_3O_8 is found. Minimum permeability in the saturated sandstone seems to be about 3 millidarcys.

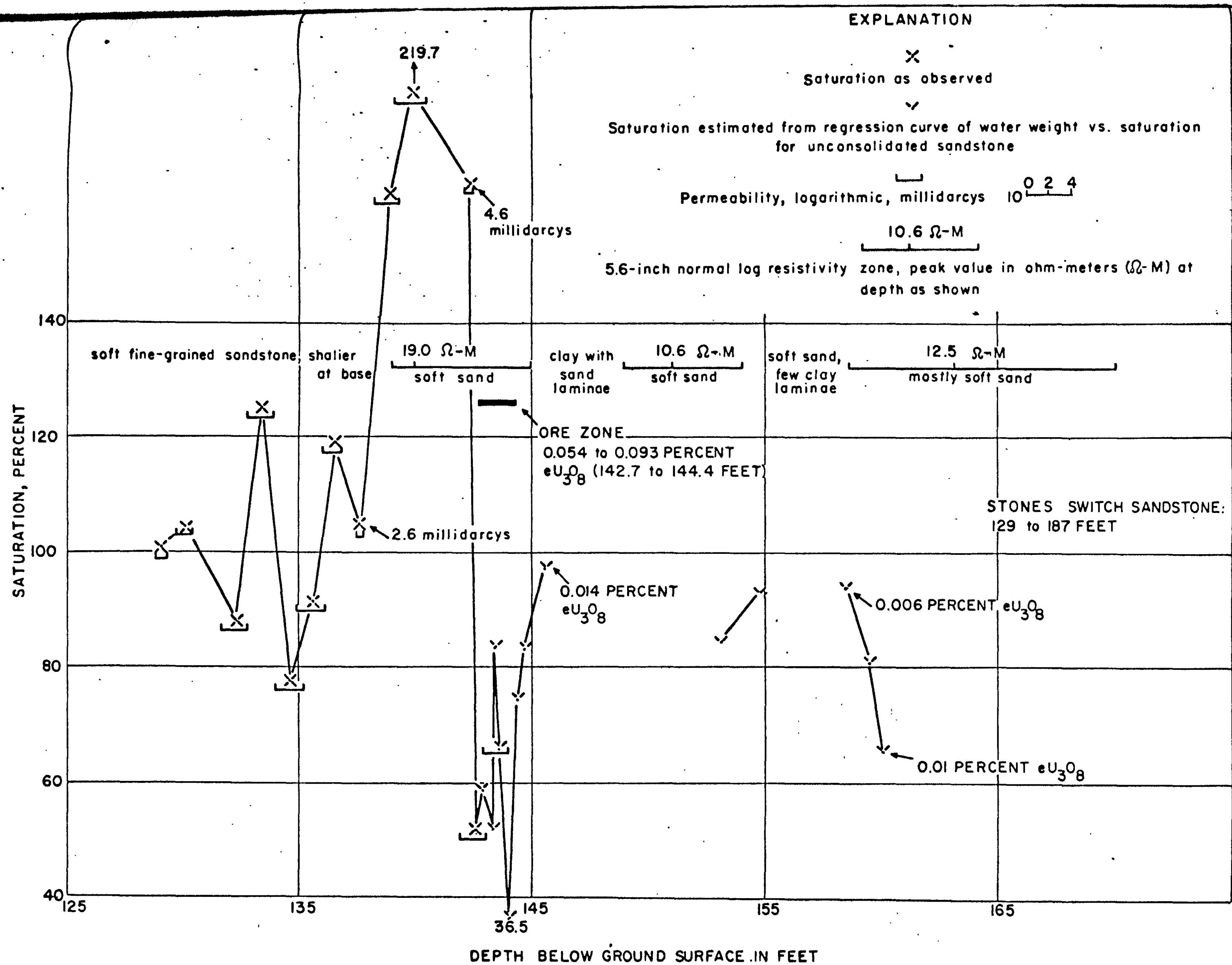


Figure 2.--Core saturation, permeability, and radioactivity, and drill-hole resistive zones in Stones Switch Sandstone Member of Whitsett Formation, drill hole K3, Karnes County, Texas.

(follows p. 12)

Normal electrical resistivity logs based on 5.6-inch electrode spacing were obtained in drill holes K1 to K5, as indicated in figures 3 to 7. These figures also show drill-hole radioactivity and eU_3O_8 content of cores. Drill hole K4 showed no abnormal radioactivity, and the few cores from drill hole K5 did not include the radioactive zone. The normal logs were recorded after the oil-base drilling fluid had been displaced by fresh water.

Induction electrical resistivity logs based on 40-inch spacing between transmitter and receiver coils were obtained in drill holes K1 (figure 8) and K2. These logs were recorded in oil-base mud in order to obtain the best approximation to formation resistivity.

Ore-grade concentrations of uranium in core from drill holes K1, K2, and K3 occur closely below the highest resistivity peak for the drill hole. A maximum peak on the gamma-ray drill-hole log also occurs below a maximum resistivity peak in drill hole K1, as shown in figures 3 and 8. Maximum radioactivity of other drill-hole logs tends to occur above maximum core radioactivity, probably indicating faulty depth registration between radioactivity and electrical logs. Prominent resistivity peaks in drill hole K4 in zones of only normal radioactivity occur opposite beds of hard sandstone where presumably porosity is relatively low, and resistivity, relatively high.

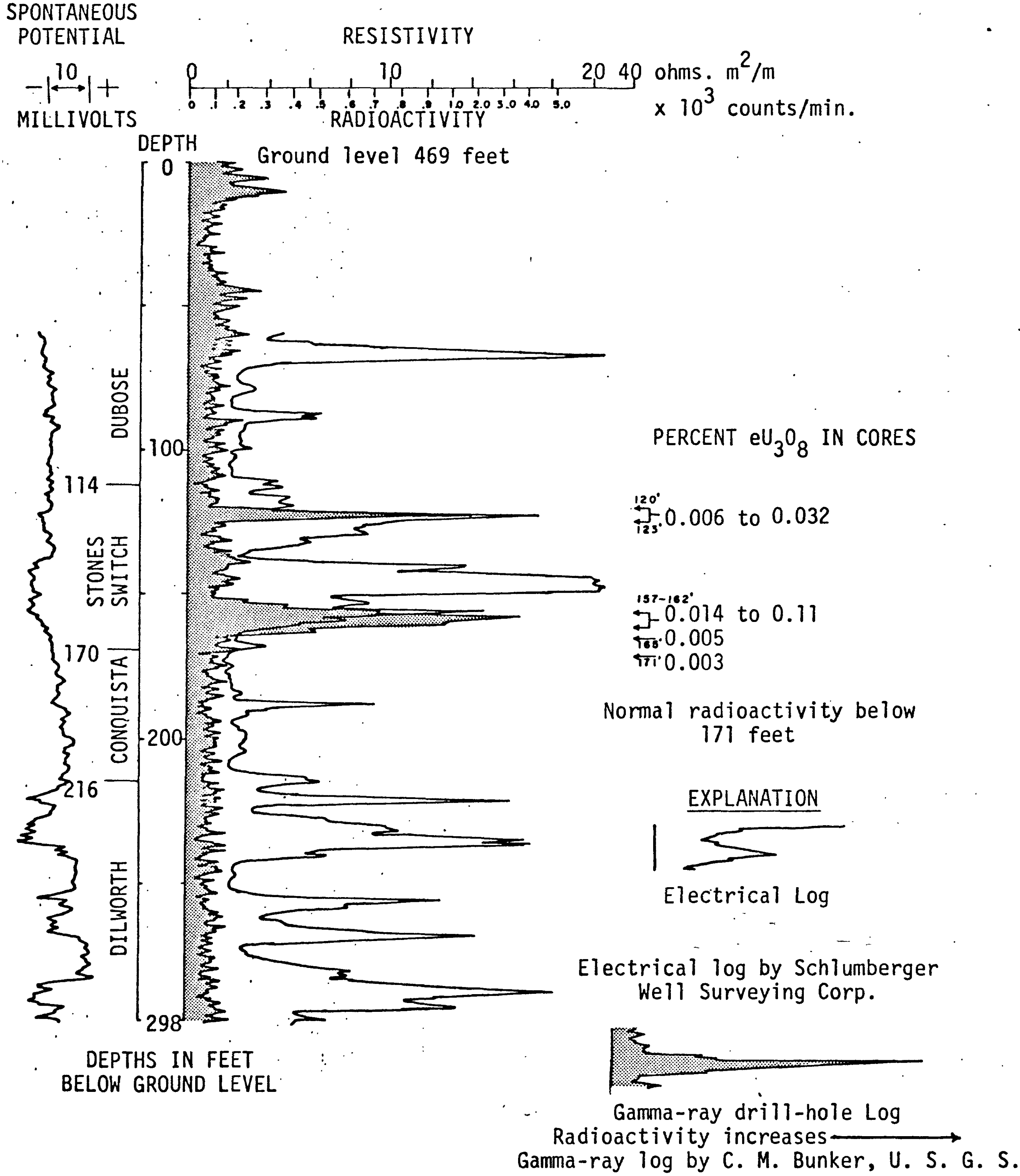


Figure 3.--Equivalent uranium oxide in cores as related to electrical and gamma-ray logs, drill hole K1, Karnes County, Texas.

(follows p. 13)

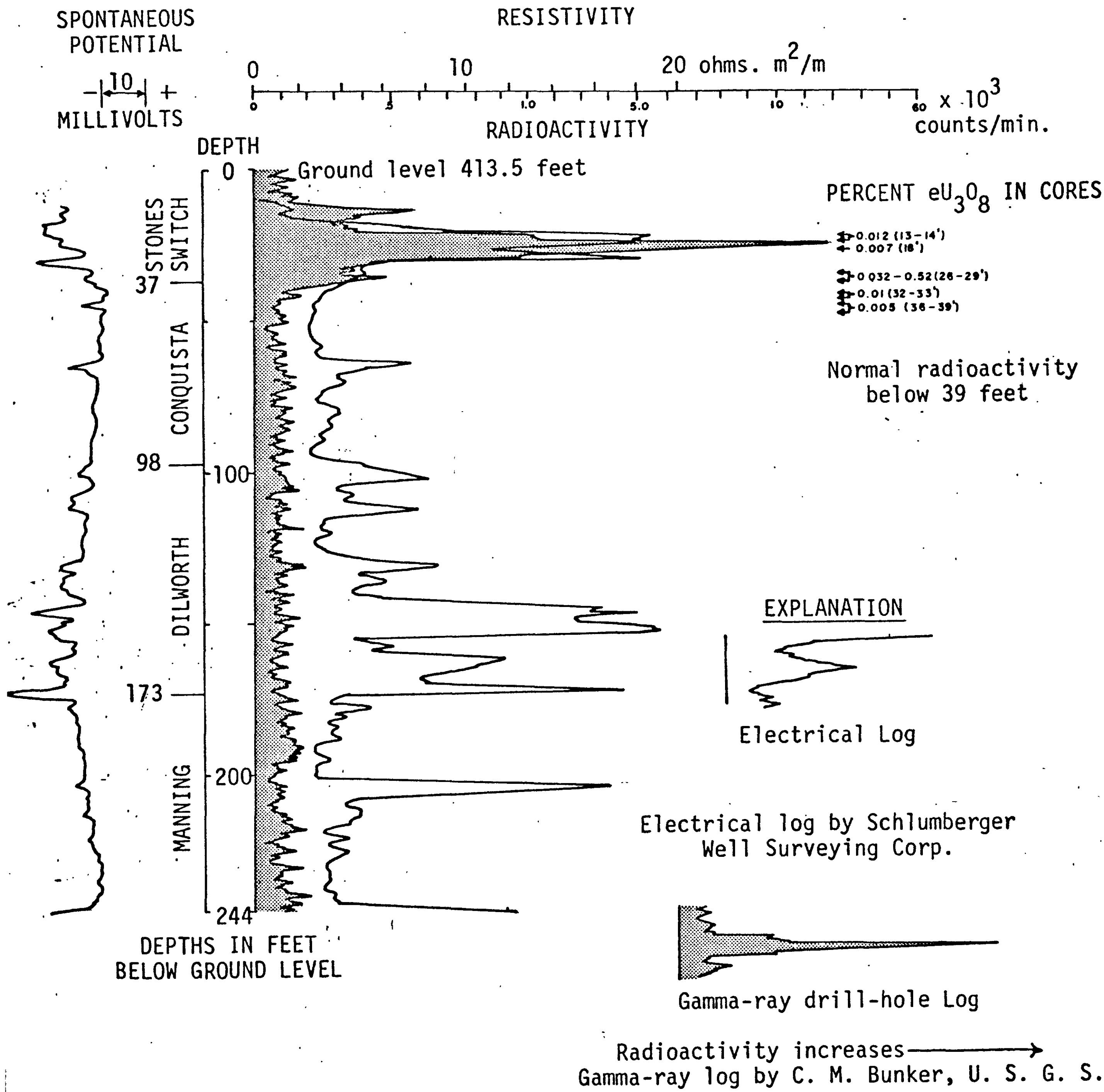


Figure 4.--Equivalent uranium oxide in cores as related to electrical and gamma-ray logs, drill hole K2, Karnes County, Texas.

(follows p. 13)

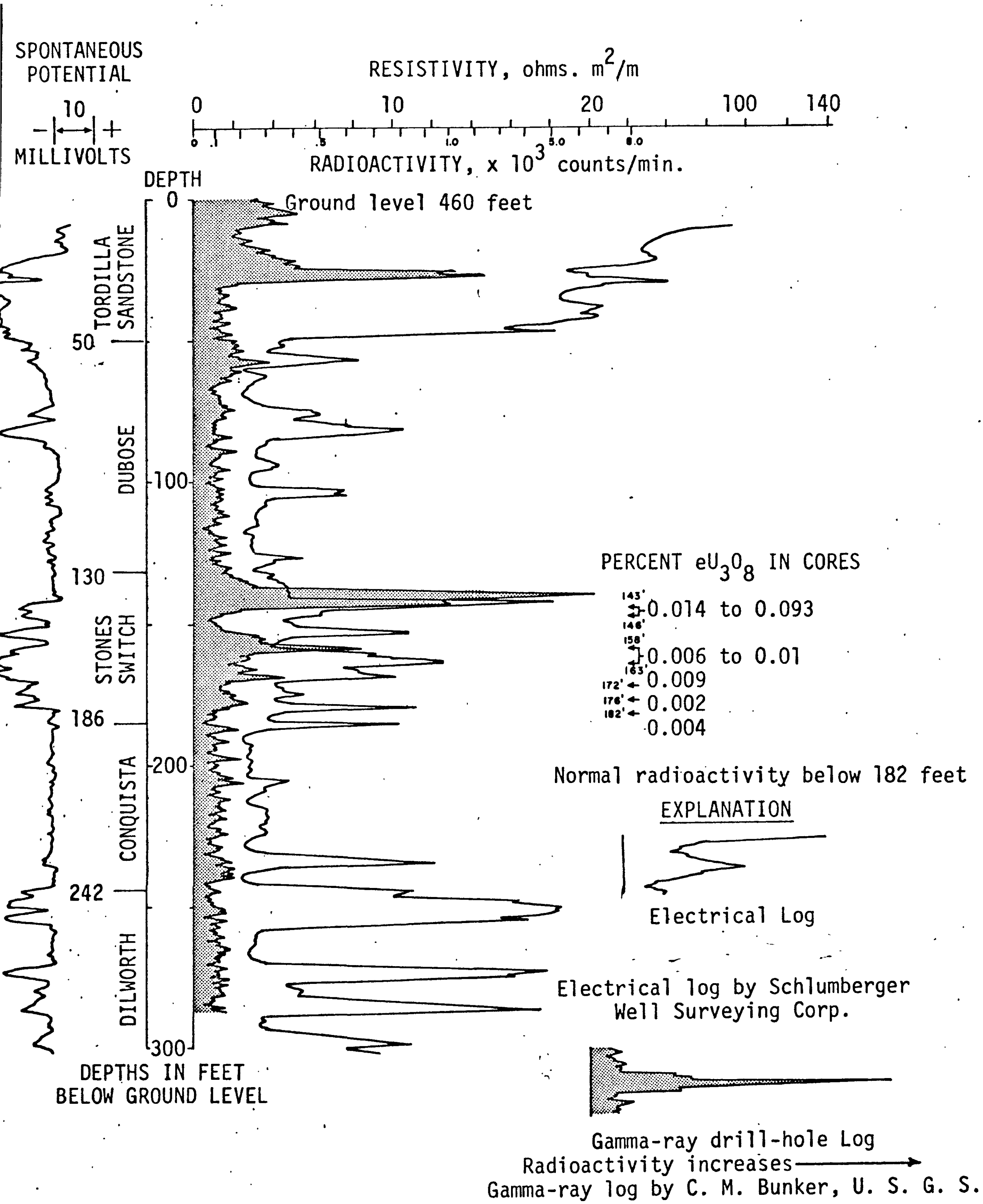
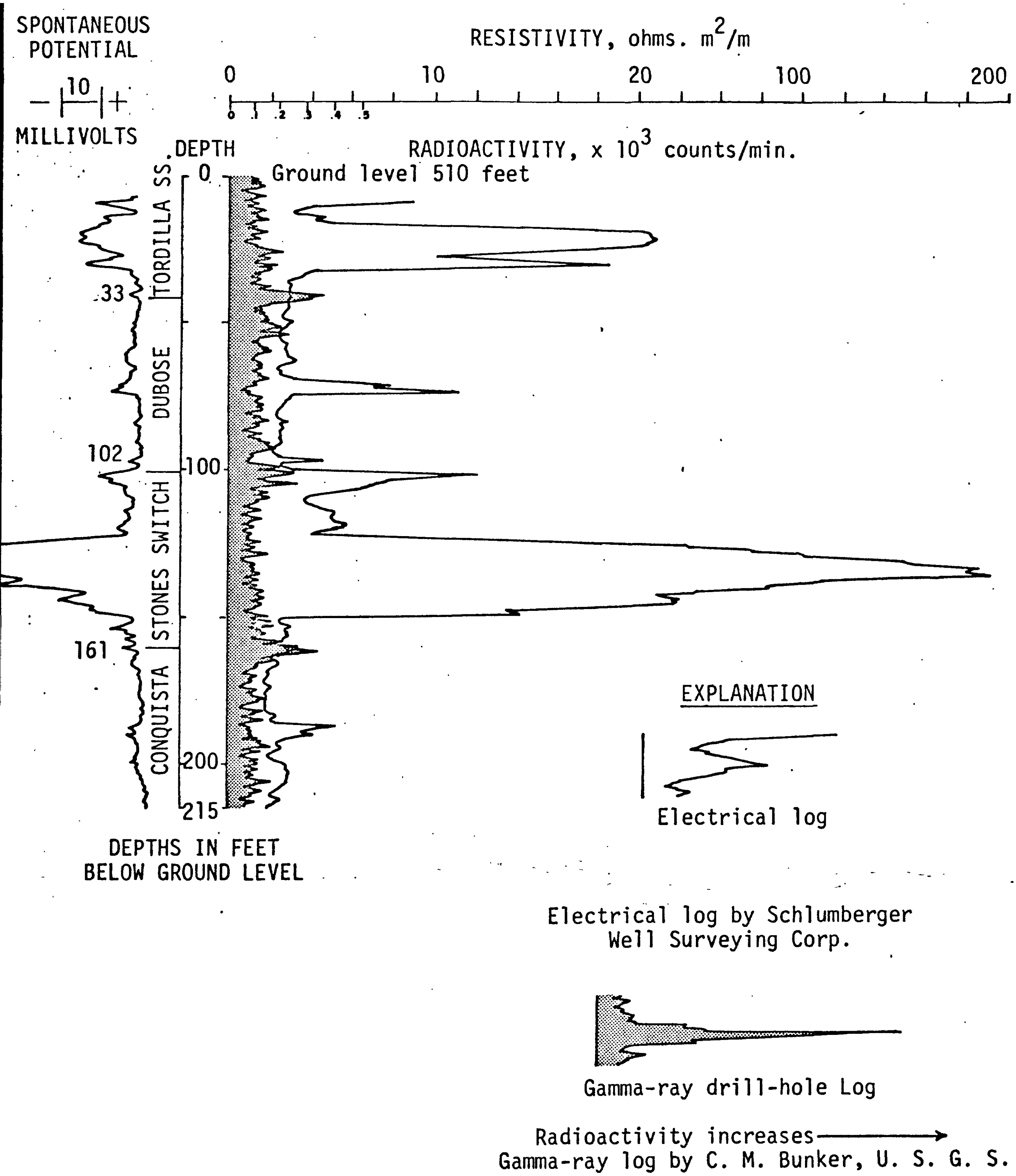


Figure 5.--Equivalent uranium oxide in cores as related to electrical and gamma-ray logs, drill hole K3, Karnes County, Texas.

(follows p. 13)



re 6.--Electrical and gamma-ray logs, drill hole K4, Karnes County, Texas.

(follows p. 13)

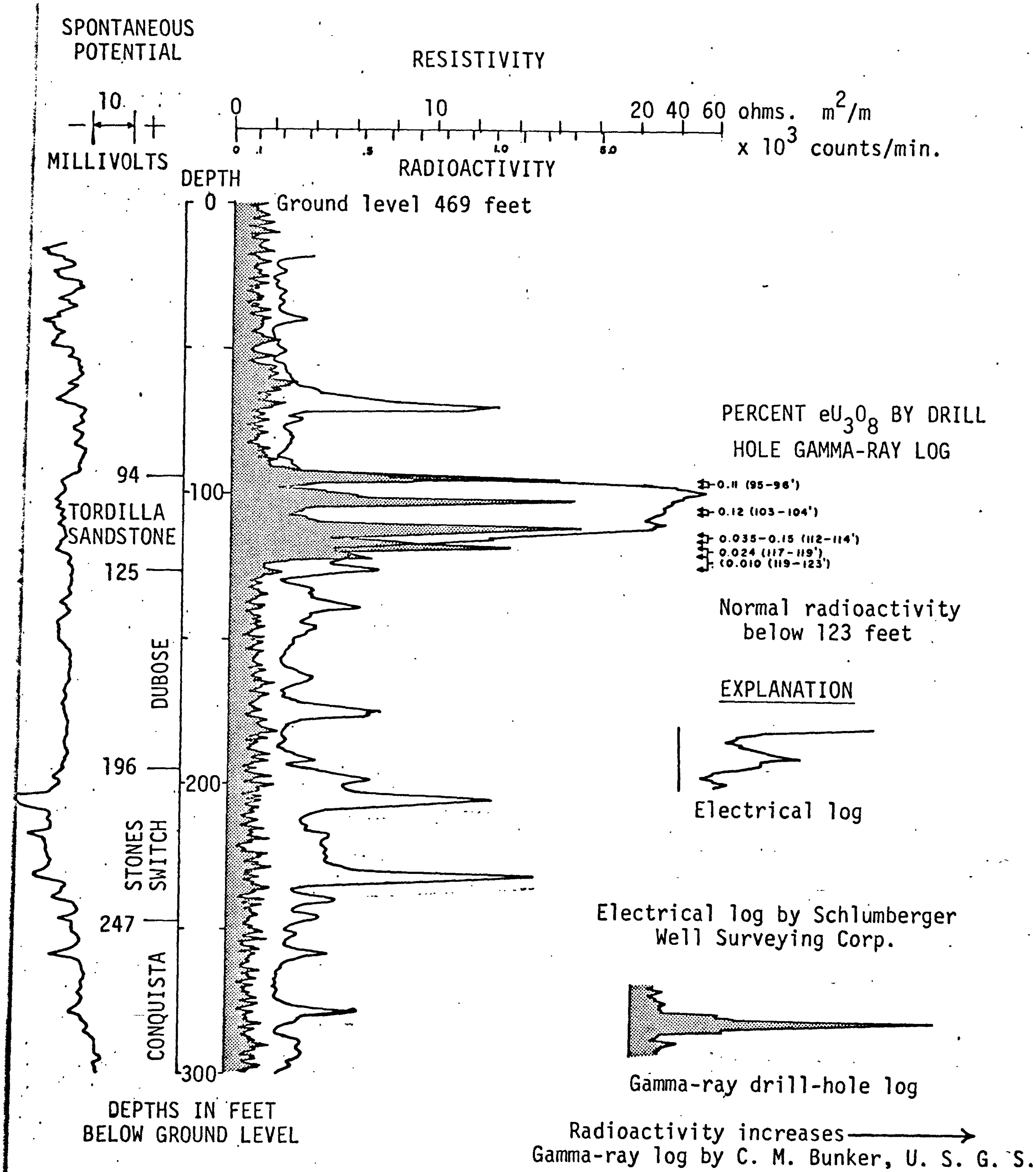


Figure 7.--Equivalent uranium oxide from gamma-ray log, and electrical log, drill hole K5, Karnes County, Texas.

(follows p. 13)

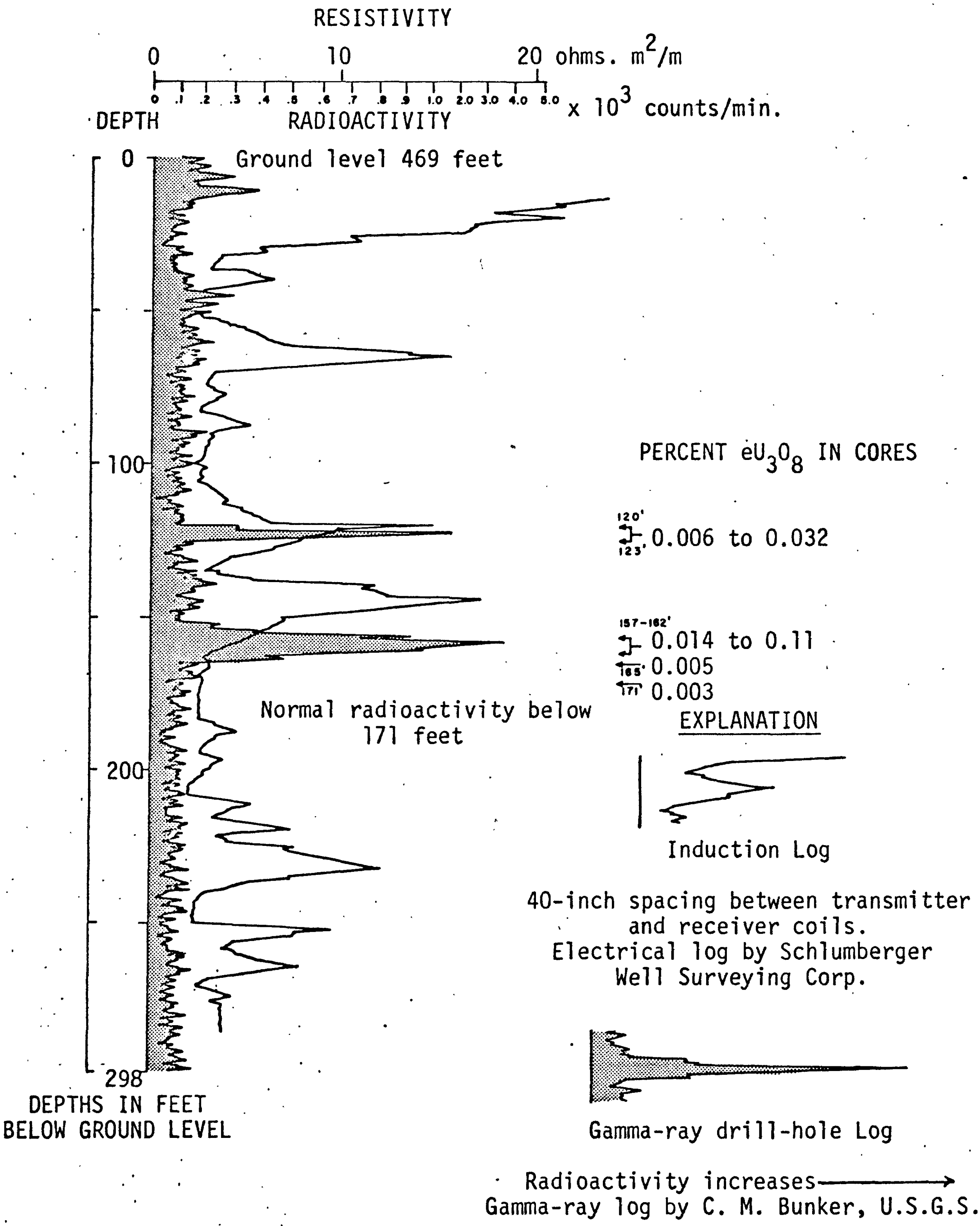


Figure 8.--Equivalent uranium oxide in cores as related to induction-log resistivity and drill-hole radioactivity, drill hole K1, Karnes County, Texas.

(follows p. 13)

Resistivity and saturation data associated with uranium ore occurrence are shown in the following table.

Resistivity-Saturation Zones				Ore		
Depth, feet	Core saturation, percent	Maximum resistivity: Depth, feet	Maximum resistivity: Value ohm-m	Depth, feet	Core saturation, percent	eU_3O_8 percent
		Drill hole K1				
139-149	62	146	15.0 1/			
149.5-171	80	154	6.0 1/	156.8-158.0	86	0.11 2/
		Drill hole K2				
16-28	56	19	14.8 1/	26.7-27.8	57	0.1-0.52 2/
		Drill hole K3				
139-145.8	74	140	19.0 3/	142.7-144.7	63	0.054-0.093 2/
		Drill hole K5				
94-106		97	52 3/	95-96		0.11 4/
				103-104		0.12 4/
107-121		109	34 3/	112-114		0.035-0.15 4/

1/ 40-inch induction log.

2/ Cores.

3/ 5.6-inch normal log.

4/ Drill-hole log.

This tabulation illustrates: (1) regular occurrence of uranium ore below a resistivity peak; (2) for drill holes K1, K2, and K3, partial unsaturation in the ore zone; (3) and for drill hole K5, where cores were not obtained, relations between resistivity and ore occurrence similar to relations in the other drill holes.

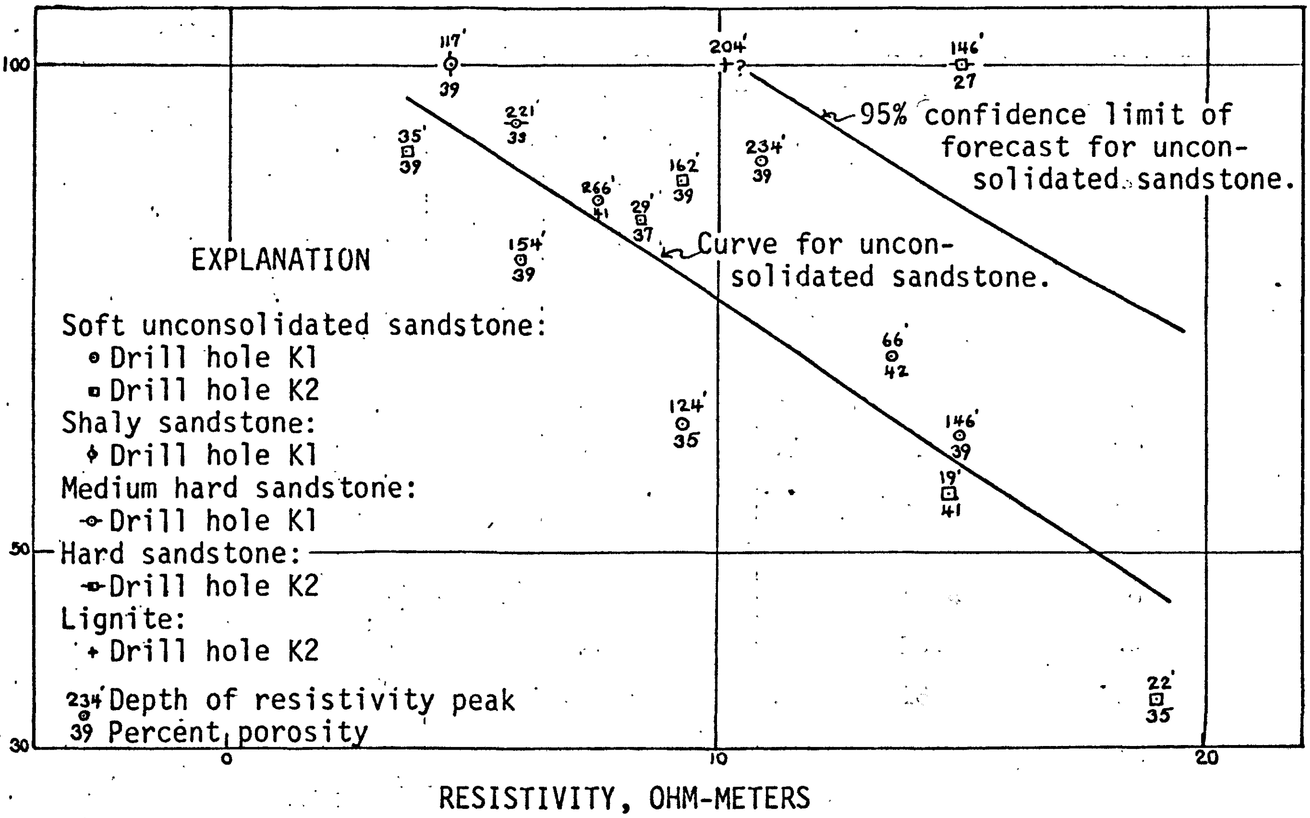
Electrical logs of drill holes K1 and K5 (figs. 3, 8, and 7) suggest that intervals from 149 to 149.5 feet in drill hole K1 and from 106 to 107 feet in drill hole K5 represent minor formation breaks that do not reflect separation of overlying saturated sandstone from underlying partially saturated sandstone. If so, respective resistivity-saturation zones extend from 139 to 171 feet and from 94 to 121 feet.

SATURATION AND RESISTIVITY LOG VALUES

The relation between formation resistivity, as indicated by induction-log resistivity in drill holes K1 (fig. 8) and K2, and formation saturation, as indicated by cores obtained by drilling with oil-base mud in these drill holes, is shown in figure 9. The regression curve is limited to points based on soft unconsolidated sandstone, or the kind of rock where uranium ore occurs. The curve indicates that unconsolidated sandstone is partially unsaturated if induction-log resistivity is 16 ohm-meters or more. Saturated harder sandstone, however, also shows higher resistivity because of lower porosity, as is indicated by the K2 sample from 146 feet, where porosity is 27 percent.

The core sample from 234 feet from drill hole K1 gives a marginal indication of partial unsaturation. If occurrence of uranium is causally related to a degree of unsaturation, possible occurrence of uranium at deeper levels at drill hole K1 should be considered, even though no radioactivity is indicated at 234 feet.

Because the 5.6-inch normal-resistivity log was recorded in all drill holes, it serves to compare values recorded by this log with those recorded by the induction log and the 16-inch normal log, as follows:



re 9.--Core saturation vs. drill-hole induction-log resistivity, Karnes County, Texas.

(follows p. 16)

Drill-Hole Resistivity, Ohm-Meters					Core
Zone depth, feet	Peak depth, feet	40-inch induction log	16-inch normal log	5.6-inch normal log	saturation, percent
	[Drill-hole diameter 5-5/8 inches. Induction log run in oil-base drilling mud. Normal logs run in fresh-water mud after displacement of oil-base mud.]				
		Drill hole K1			
? to 24	22	19.0	---	---	35
65.5 to 69	66	13.6	---	---	70
116 to 121	117	4.3	5.5	5.1	100
122 to 131	124	9.3	11.6	17.2	63
139 to 149	146	15.0	24	26	62
149.5 to 171	154	6.0	7.6	14.4	80
218.5 to 223	221	5.8	8.1	15.1	94
227 to 237	234	10.7	17.2	18+	90
263.5 to 268	266	7.4	9.1	13.5	86
		Drill hole K2			
16 to 28	19	14.8	27	---	56
28.5 to 33	29	8.4	14	18+	84
34.5 to 39	35	3.6	4.8	5.1	91
144 to 146.5	146	15.0	16.9	18+	100
158.7 to 165.3	162	9.1	9.5	11.8	88
199 to 204.5	204	10.0	11.6	18+	100?

This tabulation shows that the 5.6-inch normal log usually yields a maximum resistivity value, and the 16-inch normal, an intermediate value. It also shows that observed 5.6-inch normal resistivity of 26 ohm-meters or more probably indicates a degree of unsaturation under drill-hole conditions as noted. Thus peak values of 52 and 34 ohm-meters for the 5.6-inch normal log at depths of 97 and 109 feet in drill holw K5 probably indicate unsaturation.

LITHOLOGY OF THE CORES

Cores (or drill cuttings in zones that were not cored) were studied under binocular microscope for lithology. The logs prepared from this examination are presented in figures 10-14.

REFERENCES

Eargle, D. H., 1959, Stratigraphy of the Jackson Group (Eocene), south-central Texas: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 11, p. 2623-2635.

Krumbein, W. C., and Pettijohn, F. J., 1938, Manual of sedimentary petrology: D. Appleton-Century Co., New York, 549 p.

MacKallor, J. A., Moxham, R. M., Tolozko, L. R., and Popenoe, Peter, 1962, Radioactivity and geologic map of the Tordilla Hill-Deweesville area, Karnes County, Texas: U.S. Geol. Survey Geophys. Inv. Map GP-199.

FIGURE 1.--SECTION SHOWING CORRELATION OF BEDS CORE-DRILLED IN VICINITY OF DEWEESVILLE, KARNES COUNTY, TEXAS

(follows p. 3)

FIGURE 10,--LITHOLOGIC LOG, DRILL HOLE K1

LOCALITY

ELEV. G.L. 469 DEPTH

COORDINATES

DATE COMPLETED

LOGGED BY DATE

RECOVERY %

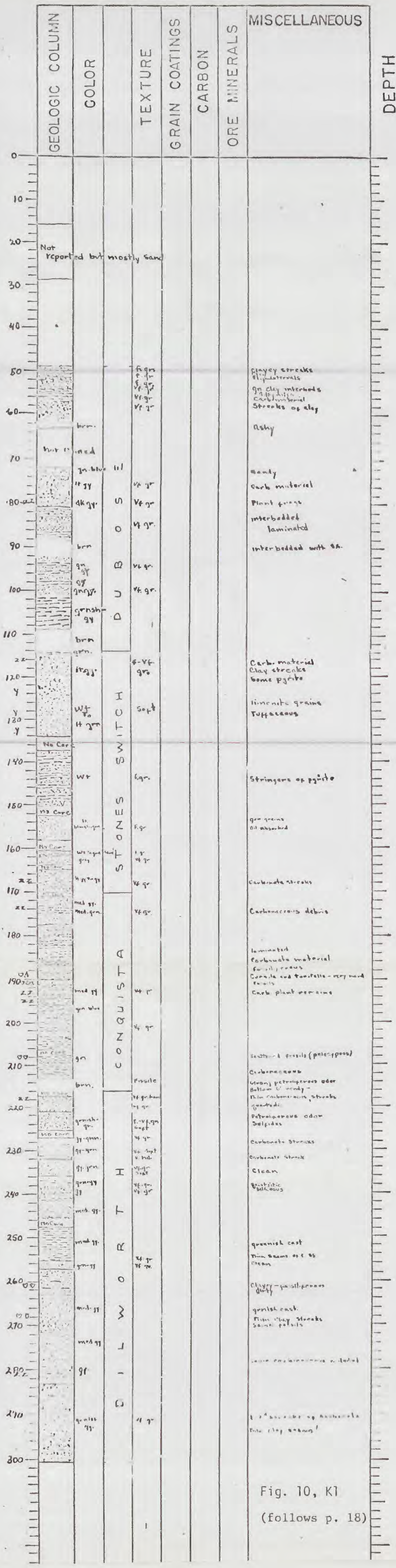


Fig. 10, K1

(follows p. 18)

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FIGURE 11.--LITHOLOGIC LOG, DRILL HOLE K2

PROJECT ____

LOCALITY Karnes County, Tex. CLAIM ____

ELEV. G.L. 413.5' DEPTH ____

COORDINATES ____ ____

DATE COMPLETED ____

LOGGED BY ____ DATE ____

RECOVERY ____ %

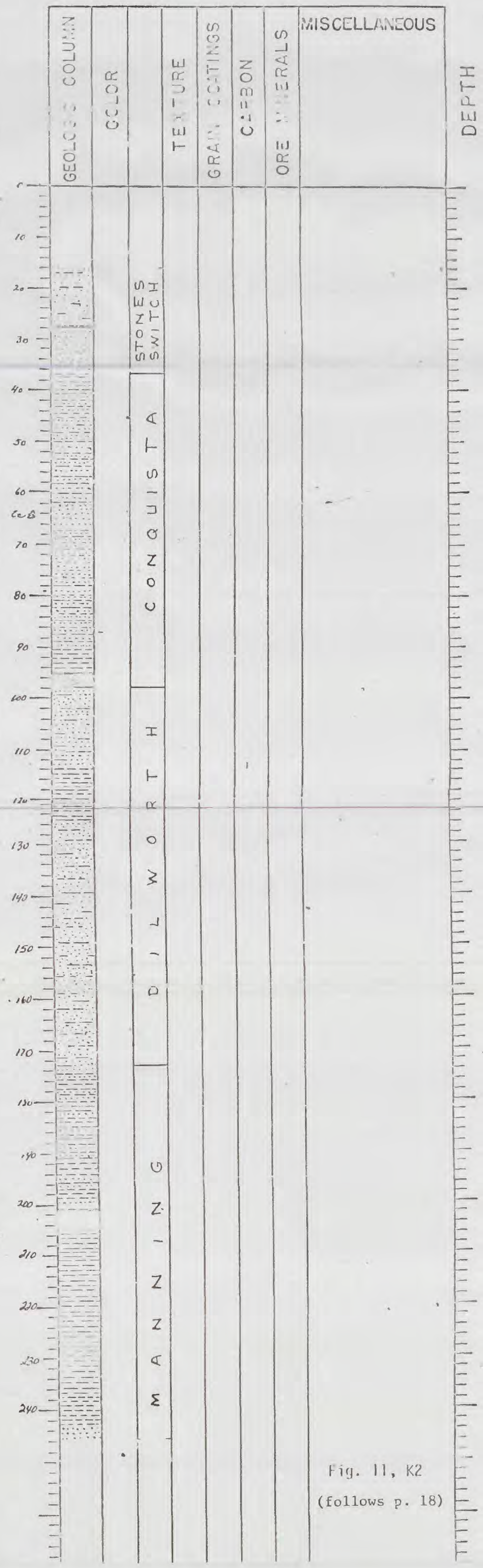

Fig. 11, K2
(follows p. 18)

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FIGURE 12.--LITHOLOGIC LOG, DRILL HOLE K3

PROJECT ______________________

LOCALITY Karnes County, Tex. CLAIM ______________

ELEV. G.L. 460' DEPTH ___________

COORDINATES ________ ___________

DATE COMPLETED ______

LOGGED BY ________ DATE ___________

RECOVERY ____ %

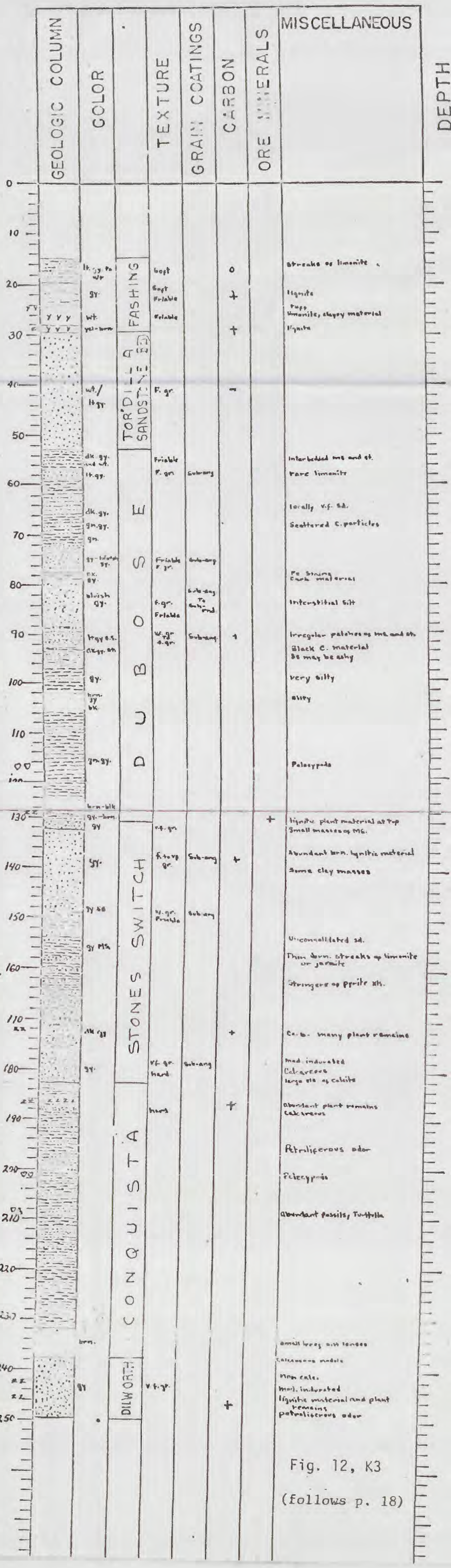

Fig. 12, K3

(follows p. 18)

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FIGURE 13.--LITHOLOGIC LOG, DRILL HOLE K4

PROJECT ______________________

LOCALITY Karnes County, Tex. CLAIM ______________

ELEV. G.L. 510' DEPTH __________

COORDINATES ____________ ____________

DATE COMPLETED ______

LOGGED BY DATE

RECOVERY

(Logged partly from cuttings)

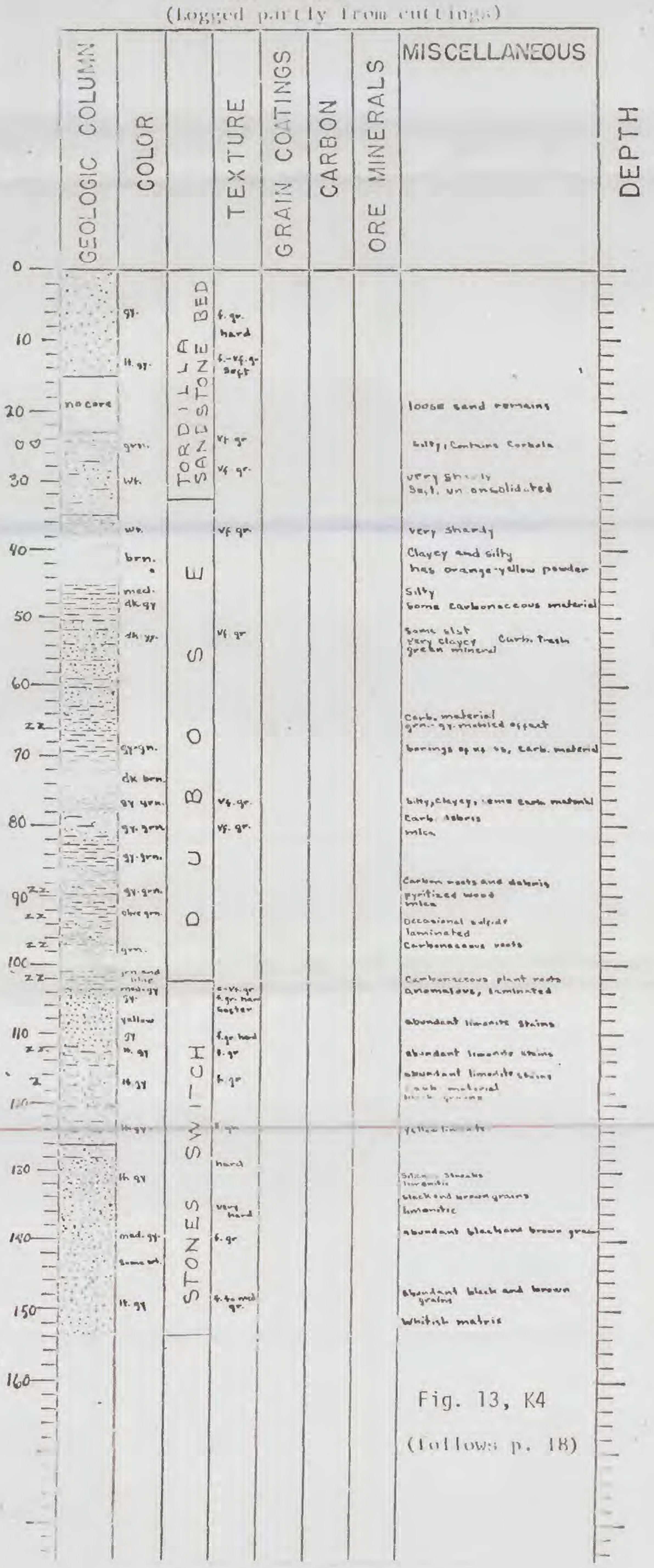

Fig. 13, K4

(follows p. 18)

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FIGURE 14.--LITHOLOGIC LOG, DRILL HOLE K5

PROJECT

LOCALITY Karnes County, Tex. CLAIM

ELEV. G.L. 495' DEPTH

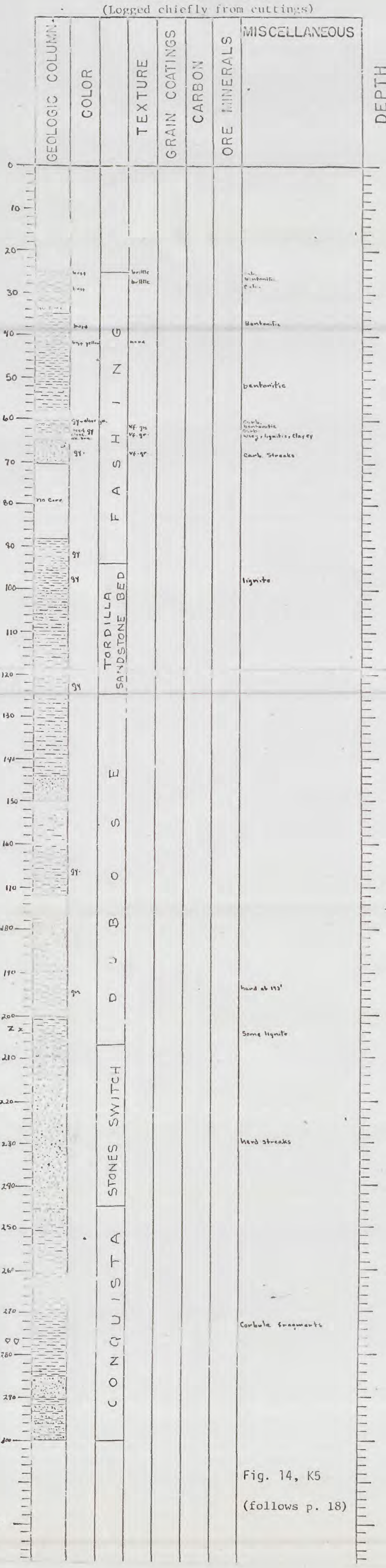
COORDINATES

DATE COMPLETED

LOGGED BY DATE

RECOVERY %

(Logged chiefly from cuttings)



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