U.S. Geological Survey

OPEN FILE REPORT

Preliminary description and interpretation of cores and radiographs from Clear Lake, Lake County, California: Core 8

by

John D. Sims and Michael J. Rymer

1975

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards

Report No. 75-306

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INTRODUCTION

Clear Lake, California is located in the California Coast Ranges about 120 km north of San Francisco and is the largest freshwater lake wholly within California. The lake basin is tectonically controlled (Anderson, 1936; Brice, 1953; Sims and Rymer, 1974) and the area seismically active (Coffman and von Hake, 1973).

Interest in this lake was stimulated by hypotheses developed from a study of sediments in Van Norman Reservoir after the 1971 San Fernando earthquake (Sims, 1973). During this study three zones of deformational structures were found in the 1 m-thick sequence of sediments exposed over about 2 km^2 of the reservoir bottom. These zones were correlated with moderate earthquakes that shook the San Fernando area in 1930, 1952, and 1971. Results of this study, coupled with the experimental formation of deformational structures similar to those from Van Norman Reservoir, led to a search for similar structures in Pleistocene and Holocene lakes and lake sediments in other seismically active areas. Clear Lake, California was chosen specifically because of its location near the San Andreas fault and the San Francisco-Oakland urban complex, and the probability of obtaining an uninterrupted sediment record from the present into Pleistocene time. Eight 12 to 15 cm diameter continuous cores were taken from the lake sediments (fig. 1) as part of a study of earthquake induced structures in sediments and the tectonic framework of the Clear Lake basin. The eight cores range in length from 13.87 m to 113.09 m (Table 1).

SUMMARY OF DATA

Core 8 is from the northwest part of Clear Lake (fig. 1) and was taken on 5 November, 1973. Depth of water at the site is 5.2 m. The core is 21.2 m long and consists entirely of olive gray (5Y3/2 to 5Y5/2) sapropellic mud (gyttja) with five interbedded volcanic ashes (fig. 2). The colors of the

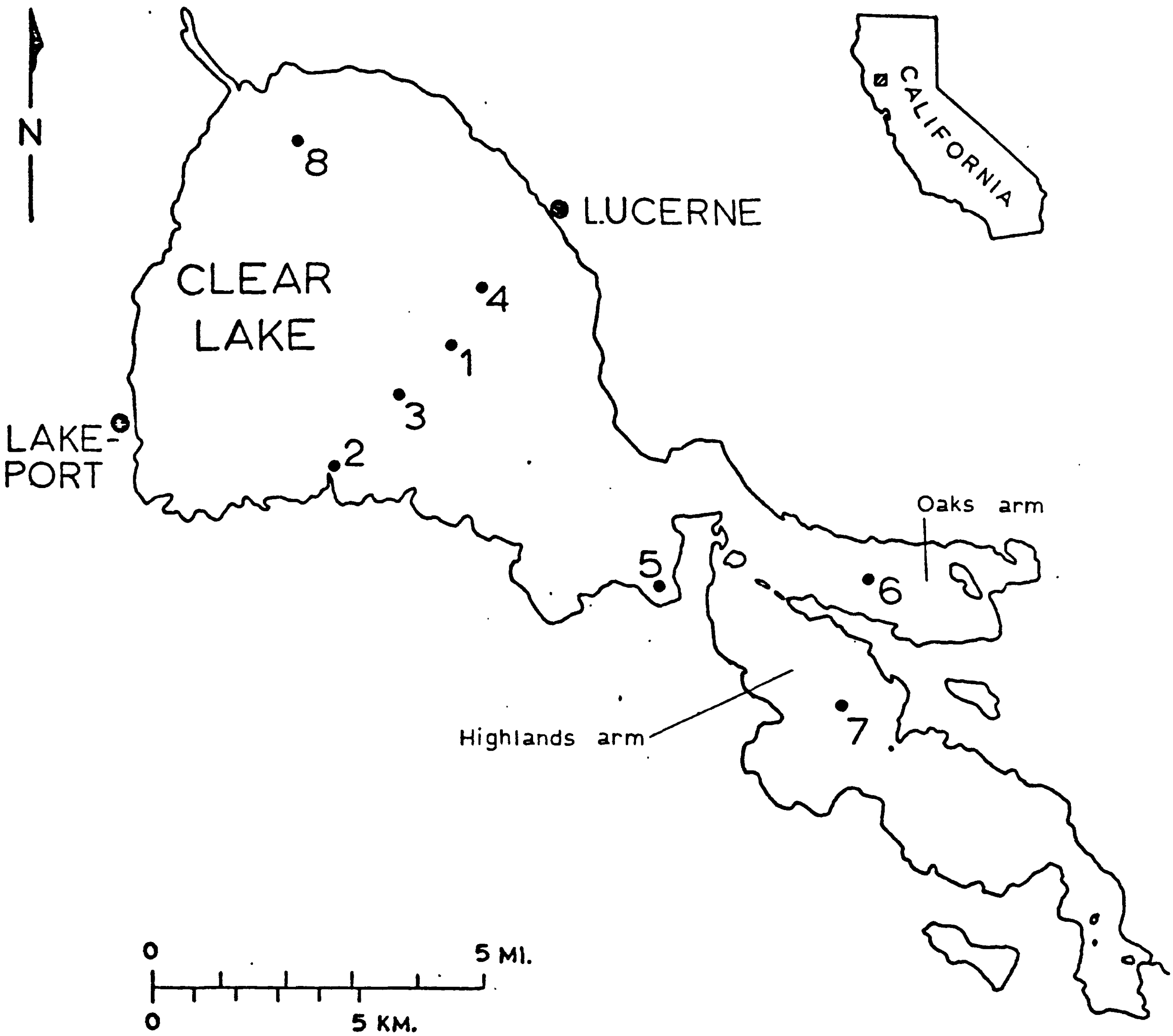


Figure 1. Map showing location of Core 8 in Clear Lake, California. Other numbered core sites in the lake are the subject of separate reports.

sediments generally recorded are those due to oxidation of the organic components. Rarely colors considered to be representative of the unoxidized sediments are recorded such as bluish gray (5B5/1). The sedimentary record in Core 8 contrasts greatly with that from Core 7 (fig. 1) (Sims and Rymer, 1975). The sediments in Core 8 represent an environment much like that prevailing in the open parts of Clear Lake today. The sediments are extensively bioturbated. This bioturbation has greatly disrupted the sediments and destroyed most of the primary and deformational (?) structures in the sediments. Thus the core is quite uniform in texture and structure throughout its length.

Five ash beds are preserved in this core. The two uppermost ash beds in Core 8 are tentatively correlated with the two uppermost ash beds in Core 7. The well preserved rhyolitic ash from Core 7, slug 17 dated at approximately 17,500 yrs. B.P. (Sims and Rymer, 1975) is tentatively correlated with the ash in slug 20, Core 8. The ash in slug 27, Core 8 is tentatively correlated with the ash in slug 23, Core 7.

Sediments in Core 8 are generally too low in organic material for ^{14}C-age determinations. However, one ^{14}C-age determination was performed. The analysis was performed by Meyer Rubin of the U.S. Geological Survey on a carbonaceous mud layer. The date (W-3214) is from slug 13 and is 9,850 $\pm$ 250 yrs. B.P. This date represents a sedimentation rate of 0.93 mm yr^{-1} for the upper half of the core. The date correlates quite well with the dates of the correlated ashes in Core 7. If the tentative correlation of the lowermost ash in Core 8 with the ash in slug 23, Core 7 is accurate then a date of approximately 24,000 yr. B.P. would represent the bottom of Core 8.

A plot of ^{14}C-age and correlated ^{14}C-age versus depth (fig. 3) shows the consistency of the age date from Core 8 and the correlated ash-age dates from Core 7. These data are fitted with a straight line by linear regression.

The equation of this line is $y=12.10x-1286.20$ and has a correlation coefficient of $r=0.999$. The line fit to the correlated data now allows a prediction of sediment ages at given depths.

Table 1. Total length and recovery percent of eight cores drilled in Clear Lake, California.

Core	Length (m)	Recovery (%)
1	52.58	35.0
2	13.87	88.0
3	69.04	96.0
4	115.21	92.0
5	22.56	94.0
6	21.64	99.0
7	27.43	94.9
8	20.52	99.6

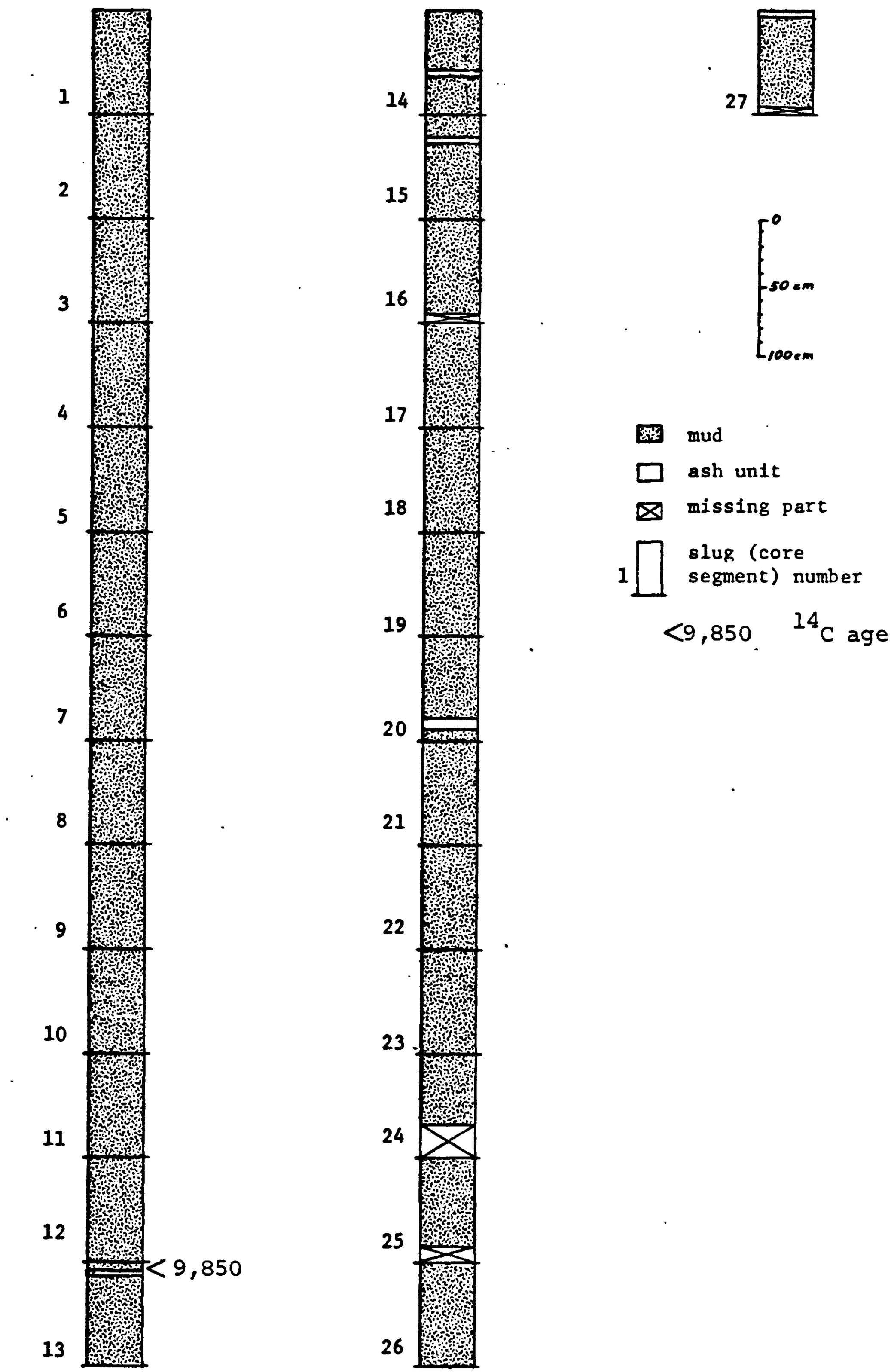


Figure 2. Generalized lithology of sediments from Core 8, Clear Lake, California.

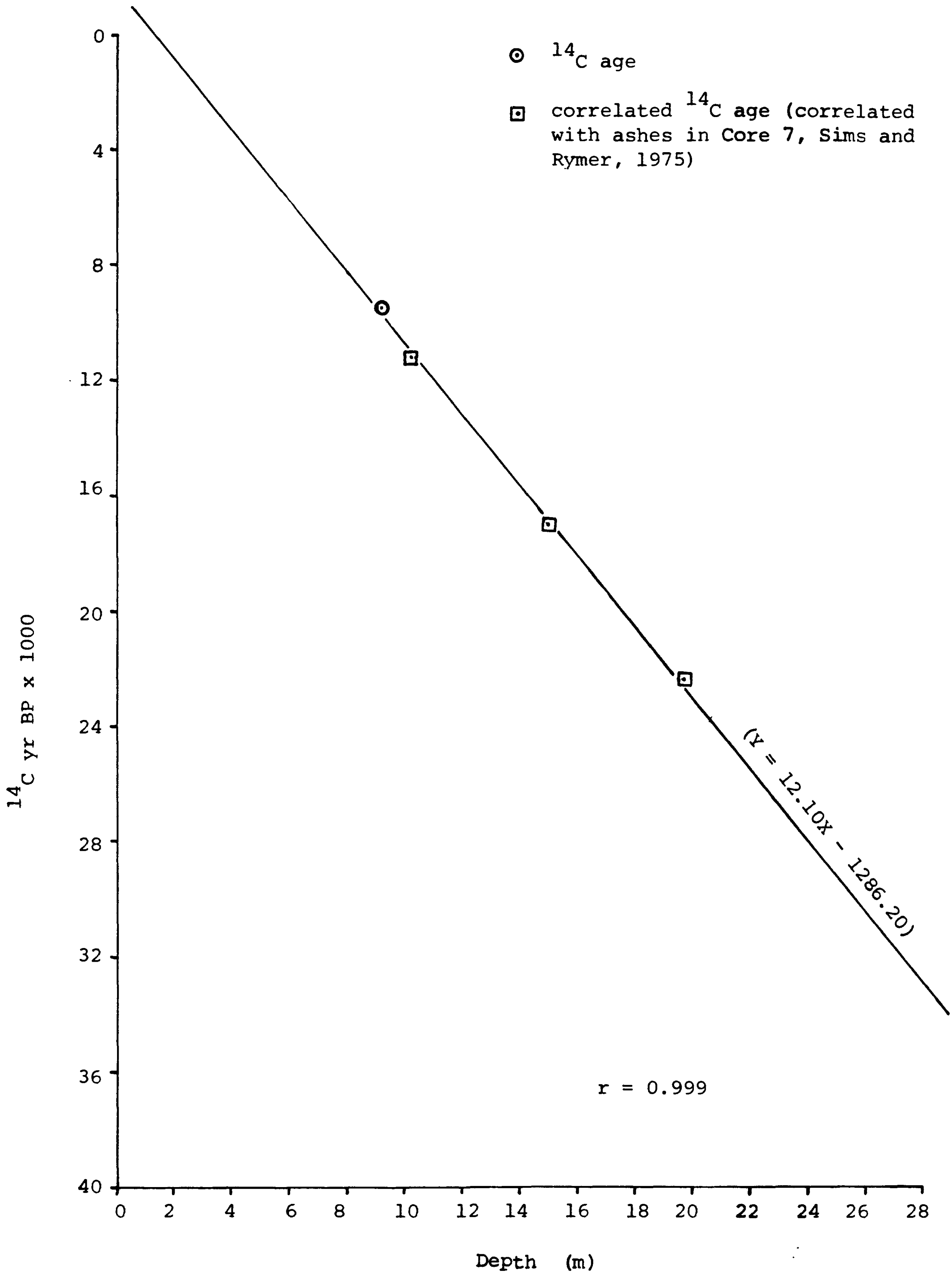


Figure 3. Plot of ^{14}C-age determination and correlated ^{14}C-age determinations and depth in Clear Lake Core 8. The line $y = 12.10x - 1286.20$ is fitted to the data by linear regression. The correlation coefficient (r) is 0.999.

METHOD OF STUDY

Core 8 was obtained using an Ostenberg sampler with a barge mounted drill rig. The samples were retrieved and extruded into rigid plastic tubes which were sealed with plastic endcaps, and waxed to prevent moisture loss. For examination the plastic containers were cut open and the core cut in half lengthwise using a "cheese cutter" type instrument. Lithologic and other sedimentologic data were then recorded (see Appendix A for detailed descriptions). One-half of each core segment was photographed on color and black and white film. Then a one cm thick slice was taken from the center of the core segment and an x-ray radiograph made to study the internal structures and fine details of the visible structures.

The original x-ray radiographs were taken on 30 x 43 cm sheets of industrial x-ray film at 1:1 scale. Exposures to x-radiation ranged from 4 to 6 minutes at 45 KV and 3.5 ma. The prints from the radiographs in Appendix B of this paper are photographically reduced 3.7x from the originals.

After lengthwise splitting, samples were taken from one-half of the core for other sedimentologic and paleontologic studies as follows:

a) bulk mineralogy

b) cladocerae

c) diatoms

d) fine grain size analysis (<125 μ diameter)

e) macro fossils

f) pollen

g) water content/organic carbon content

The remaining core half, resting in a rigid plastic half-round, was sealed in a polyethelane bag and retained for future use and reference.

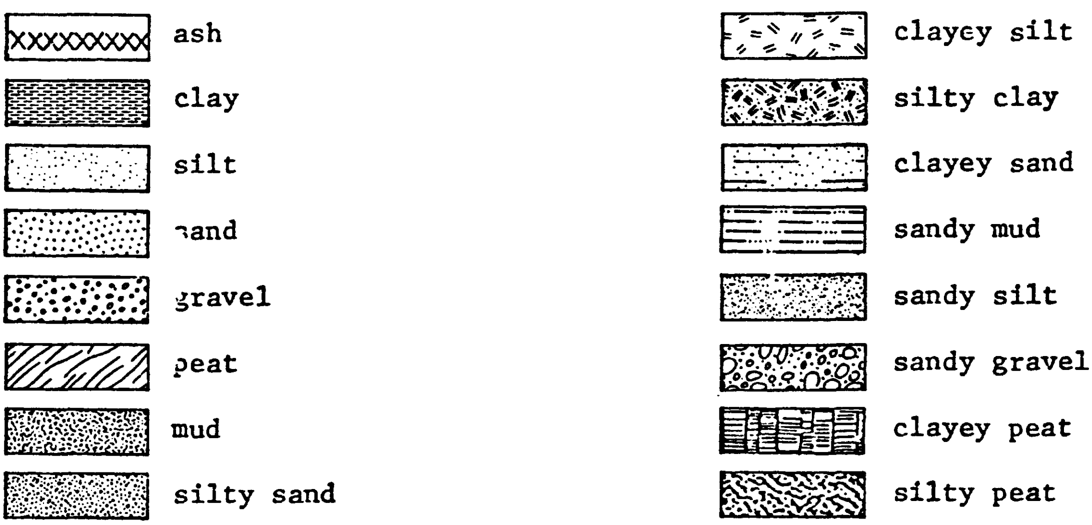
These samples and the original radiographs may be examined by contacting:

John D. Sims
U.S. Geological Survey
Earthquake Tectonics Branch
345 Middlefield Road
Menlo Park, California 94025

GRAPHIC NOTATIONS USED IN STRATIGRAPHIC DESCRIPTIONS

The stratigraphic descriptions of each core segment (slug) are contained on individual sheets in the format shown in fig. 4. The graphical notations used in the core descriptions and radiograph interpretations in Appendix B are modified from the methods of Bouma (1962). The conventions and symbols used follow: Those symbols marked* are also used in the column entitled Radiographic.

Lithology



D — material from sides of hole as a contaminant, generally at the top of a sample (debris).

v — vivianite, an iron phosphate present in the sediments.

interlaminated strata; dominant lithology on left (in this example clayey peat and mud)

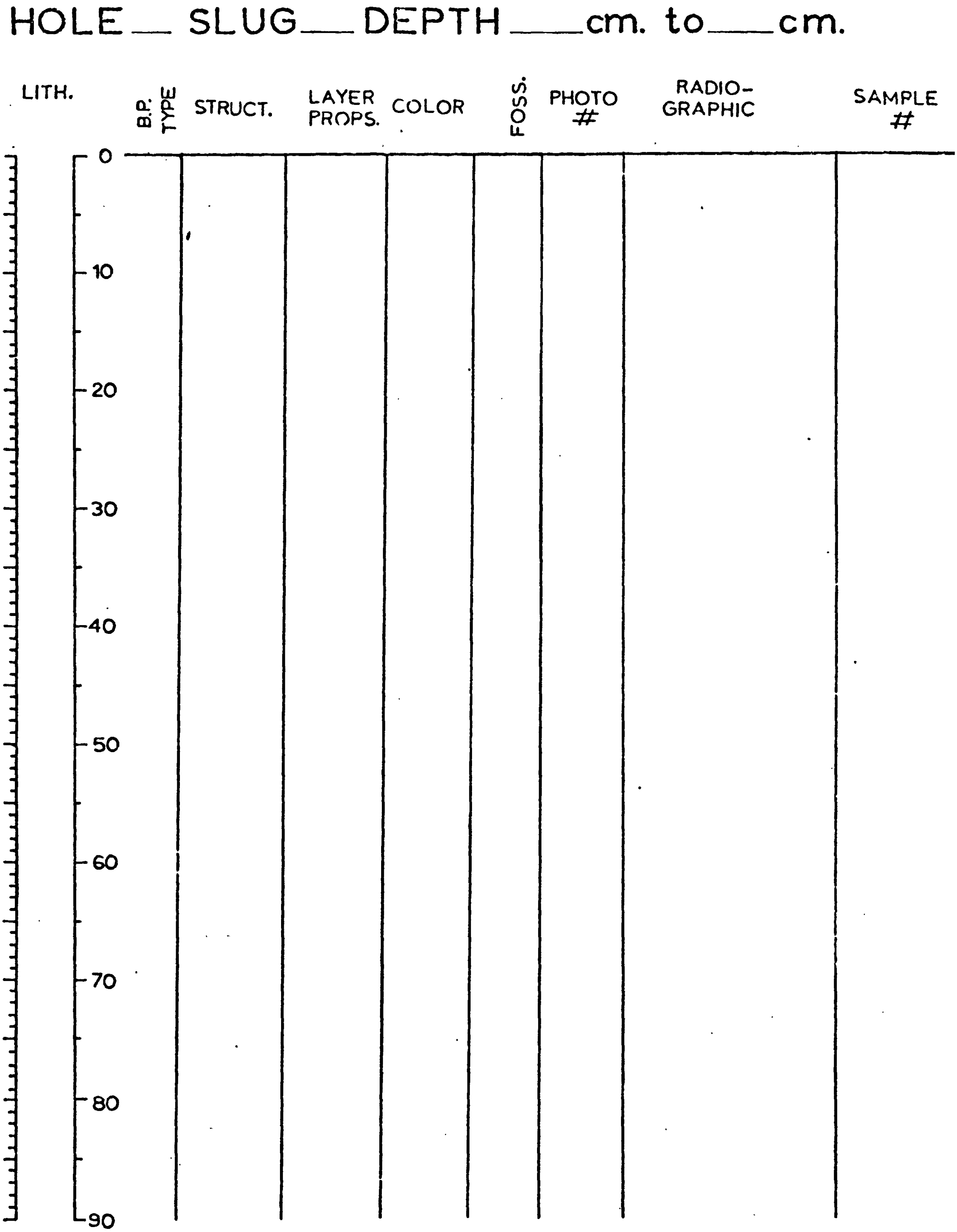
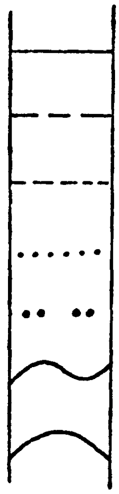


Figure 4. Form for stratigraphic descriptions of core segments (slugs) Column headings from left to right are Lithology, Bedding plane type, Bedding plane structures, Layer properties, Munsel Color designation, Fossil content, Photograph numbers, Radiographic interpretation, and Sample numbers.

Bedding Plane Type*



Sharp flat contact

distinct flat contact

transition (range of transition < 0.5 cm)

gradual transition (range of transition 0.5-1.0 cm)

transition gradual and hardly visible (range of transition > 1.

undulating contact; gradations as above

irregular contact; gradations as above

Structure

graded bedding

load cast

earthquake induced structure*

fault*

Interval in which structure occurs*

indistinct structure* ( )

structure barely visible* (( ))

Layer Properties

parallel lamination (< 0.5 cm thick)*:

coarse laminae predominate

---

fine laminae predominate

parallel lamination* — slightly disturbed / strongly disturbed

* Also used in column entitled Radiographic

parallel wavy lamination*

(predominating thickness and degree of disturbance as noted above)

lenticular wavy lamination*

(predominating thickness and degree of disturbance as noted above)

interval in which property occurs*

indistinct property* ( )

Color

Color designations are taken from the Munsell Soil Color Chart (Munsell, 1973). Conventions used are as follows:

$\frac{\text{10Y 5/4}}{\text{5YR 5/4}}$	distinct color break between between two units.
10Y 5/4/5YR 5/4	two colors present throughout the interval noted. First color is most prevalent and the right hand color is present as clots, belbs, or patches.
10Y 5/4 | 5YR 5/4	distinct interlamination throughout the interval noted.
10Y 5/4 (5YR 5/4)	oxidized color (unoxidized color) this notation is used only where partial oxidization of the sediments has occurred and the unoxidized color is readily apparent.

Fossils

fish scale*

fish bone*

* Also used in column entitled Radiographic

gastropod*

clam*

root

root level

wood oriented parallel to bedding plane

wood not parallel to bedding plane

plant fragment parallel to bedding plane

plant fragment not parallel to bedding plane

Photograph Number

Numbers refer to the index number of both the color and black and white photos taken of the cut surface of the core segment.

Example: 7-1-1 refers to Core 7, Slug 1, Photo 1.

There are 5 photos for each slug in Core 8. Each photo covers approximately 20 cm of core segment length with overlap with adjacent photos.

These photos may be examined and copies made at the requestor's expense by contacting:

John D. Sims
U.S. Geological Survey
Earthquake Tectonics Branch
345 Middlefield Road
Menlo Park, California 94025

* Also used in column entitled Radiographic

Radiographic

This column contains supplementary information derived from an analysis of information taken from x-ray radiographs. The notations used in this column are a combination of those marked by * under the headings Bedding Plane Type, Bedding Plane Structure, Layer Properties, and Fossils, plus some additional special symbols not previously used (list below):

granule - an x-ray opaque small body < 1 mm in diameter.

granule cluster - a regularly to irregularly shaped mass of granules.

pebble - a large (> 3 mm diameter) x-ray opaque body.

mottling - areas of low x-ray transparency of irregular shape and unknown origin.

bioturbation - animal burrows. The degree of sediment disturbance generally accompanies this note such as: heavy, slight, etc.

$\Delta\delta$ - a difference in x-ray transparency between stratigraphic subunits due to compositional, grain size or other physiochemical differences.

fractured - physical breaking of the indicated part of the sediment slice that usually occurred during sample preparation prior to x-ray inspection.

plastic - plastic chips derived from sawing the rigid plastic core container.

Sample Number

Three types of sample numbers are present and identify samples taken for specific tests or supplementary data. The specific use and identity of samples are as follows:

1) Four digit numbers without a prefix are reserved for bulk mineralogy, fine grain size analysis (fraction < 125 μ diameter), fossil cladocerae, palynological examination, weight loss on drying, fossil diatoms and macrofossil content.

2) Four digits prefixed by "I" (example: I-7030). A radiocarbon date performed by Mr. James Buckley in the laboratories of Isotopes, Inc., Westwood, N.J. The absolute date and all pertinent data are listed at the bottom of the page on which the sample number occurs.

3) Four digits prefixed by "W" (example: W-3030). A radiocarbon date performed by Mr. Meyer Rubin in the laboratories of the U.S. Geological Survey, Reston, VA. The absolute date and all pertinent data are listed at the bottom of the page on which the sample number occurs.

Acknowledgements;

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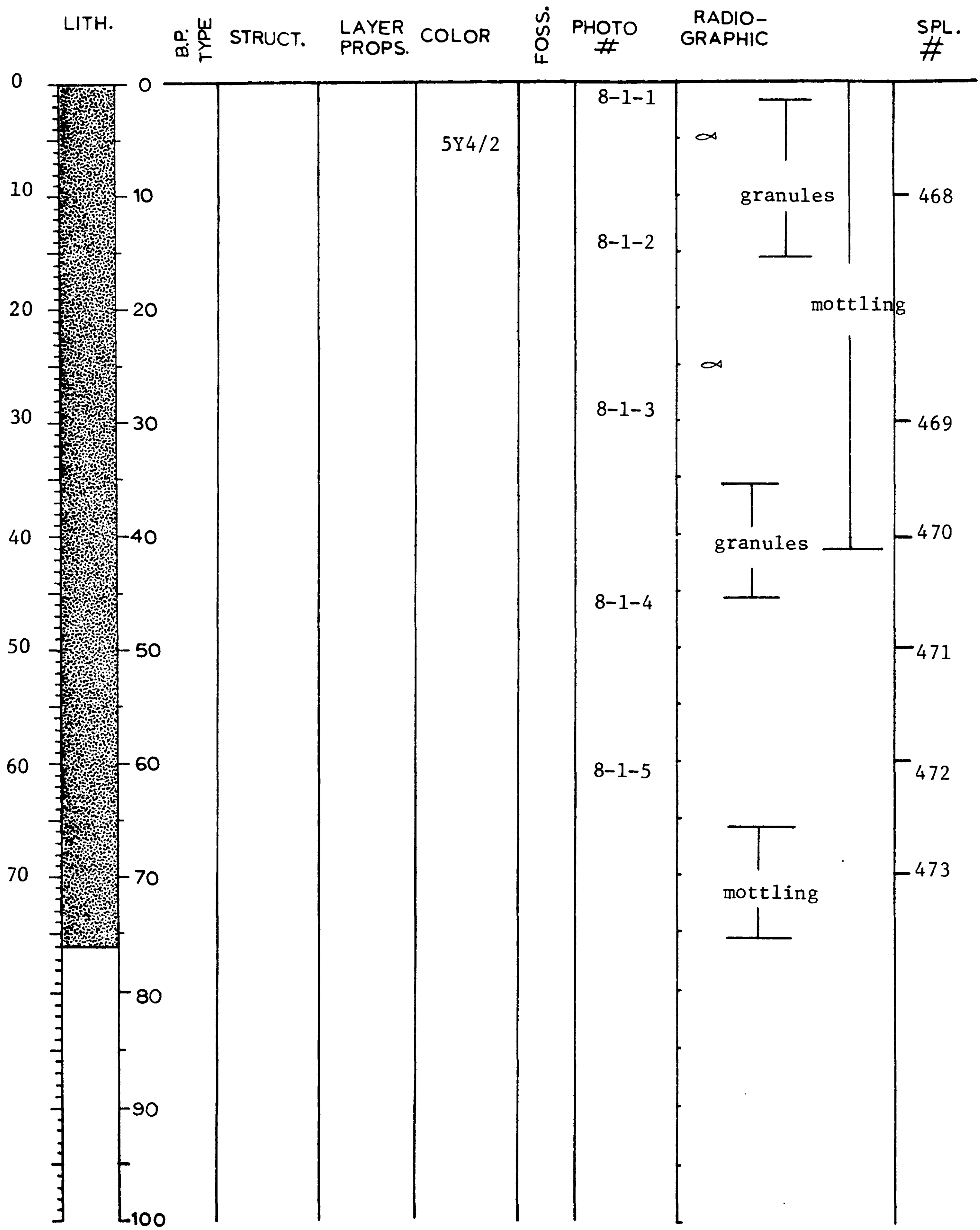
Appendix A

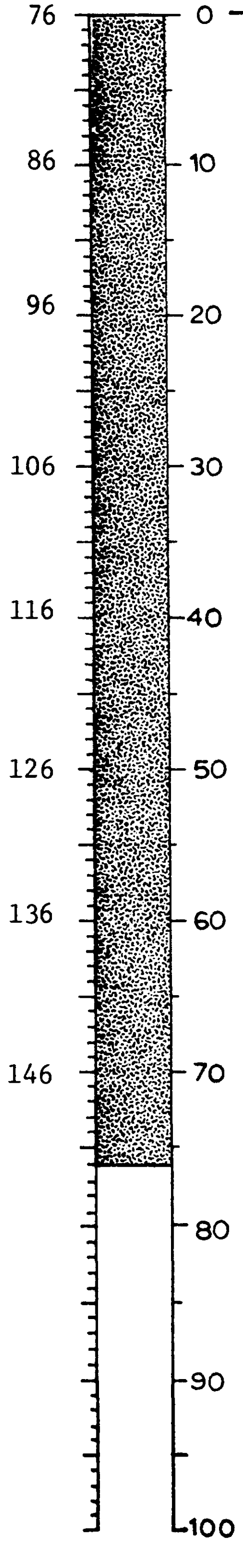
Graphical Logs

HOLE 8 SLUG 1 DEPTH 0 cm. to 76 cm.



bioturbation throughout

HOLE 8 SLUG 2 DEPTH 76 cm. to 152 cm.



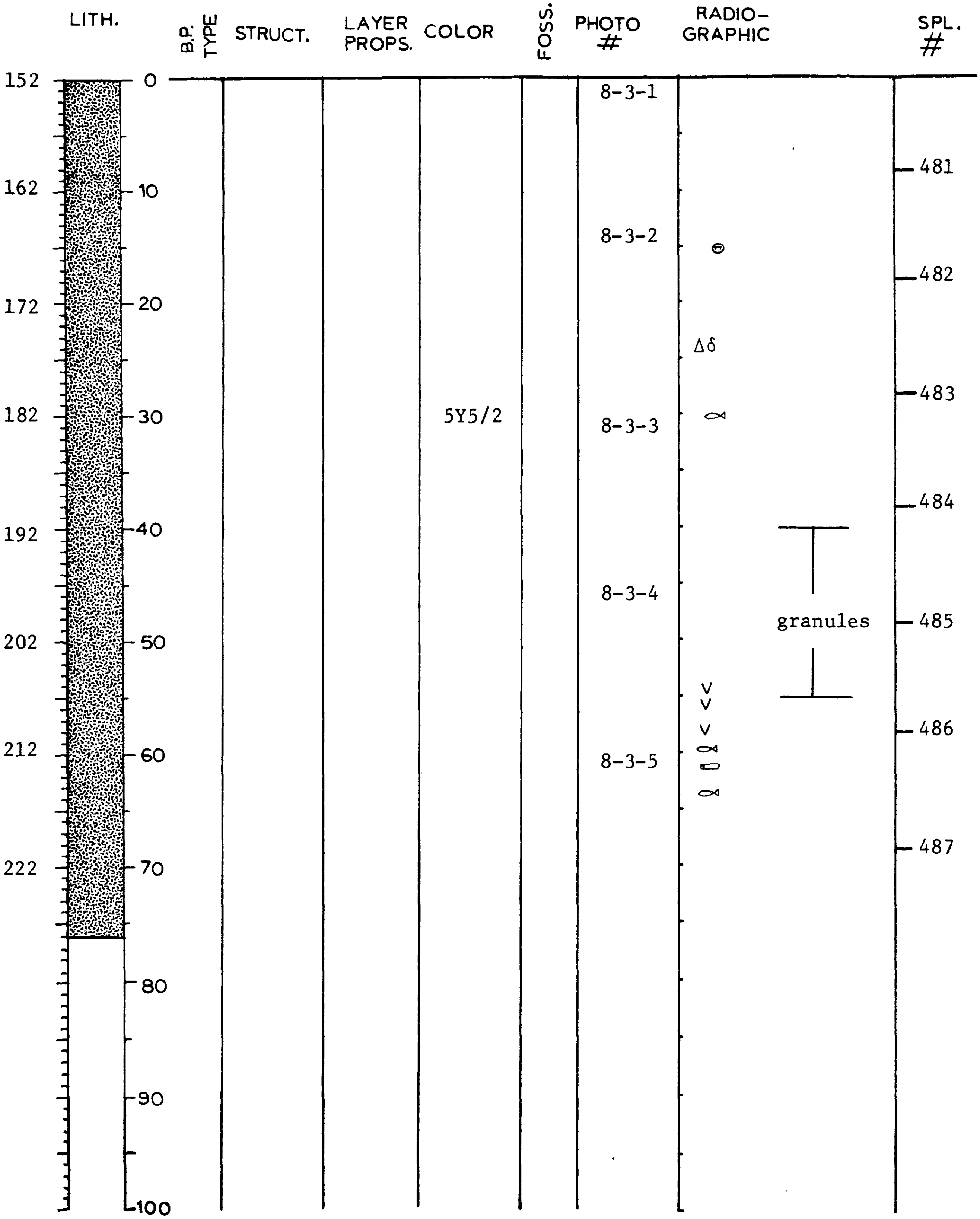
B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIOGRAPHIC	SPL. #
					8-2-1		
							474
							475
					8-2-2		
							476
					8-2-3	granules	
							477
			5Y4/2				
							478
					8-2-4		
							479
					8-2-5		
							480
						granules	

slight mottling and bioturbation throughout

1 cm oxidation on both sides of crack at 118 cm

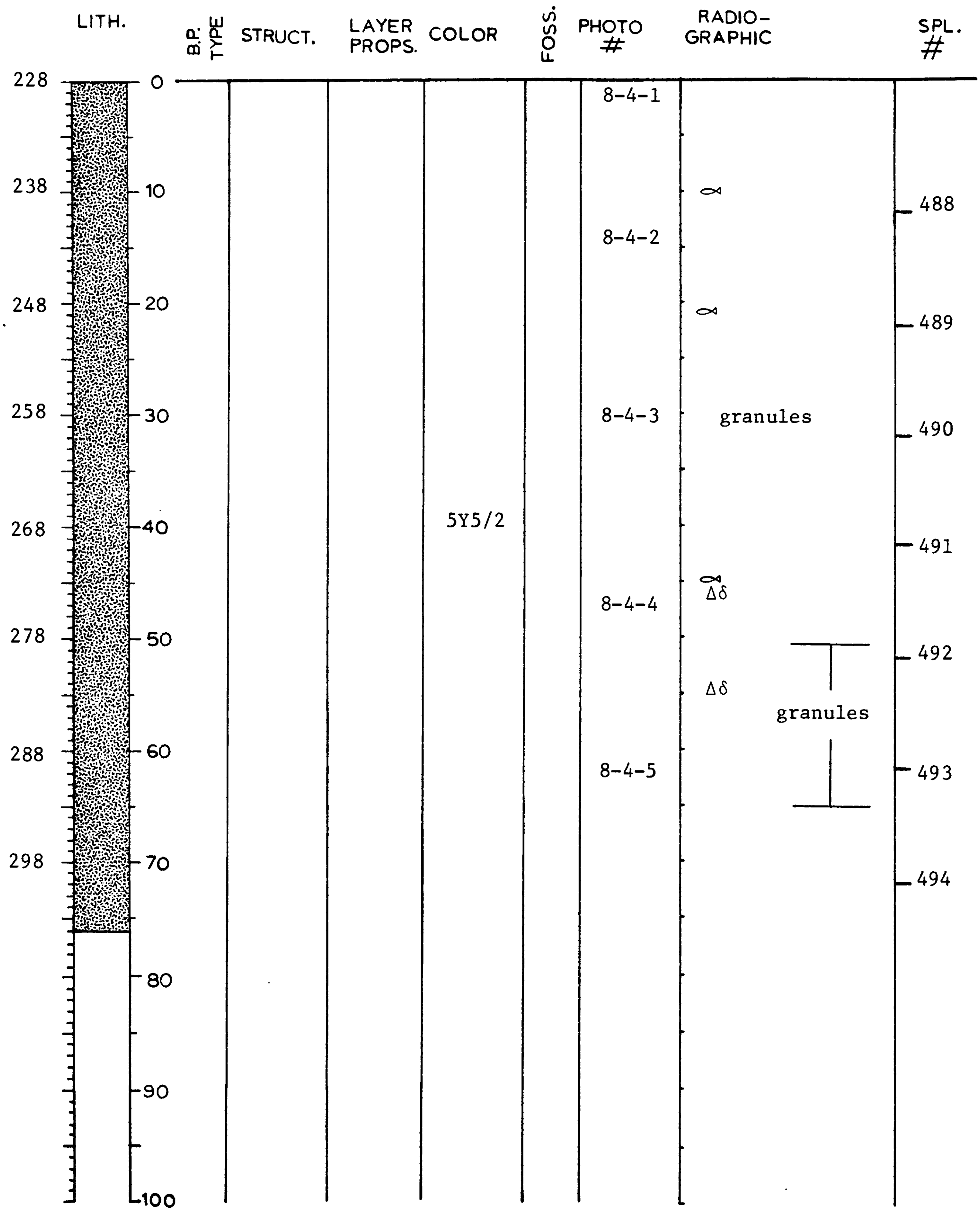
disseminated fish bones throughout

HOLE 8 SLUG 3 DEPTH 152 cm. to 228 cm.



slight mottling and bioturbation throughout

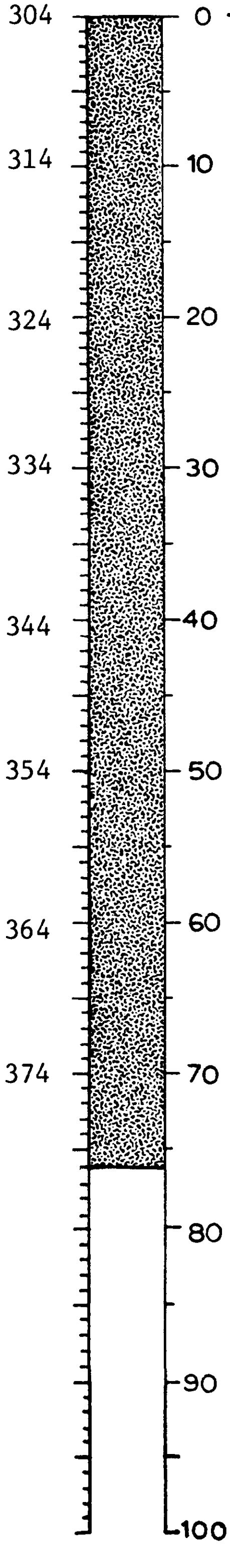
HOLE 8 SLUG 4 DEPTH 228 cm. to 304 cm.



bioturbation throughout

HOLE 8 SLUG 5 DEPTH 304 cm. to 380 cm.

LITH. | B.P. TYPE | STRUCT. | LAYER PROPS. | COLOR | FOSS. | PHOTO # | RADIO-GRAPHIC | SPL. #



5Y5/2

8-5-1
8-5-2
8-5-3
8-5-4
8-5-5

fish bone dragged along when core was cut

495
496
497
498
499
500
501

slight mottling and bioturbation throughout

HOLE 8 SLUG 6 DEPTH 380 cm. to 456 cm.

Depth (cm)	LITH.		B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
380		0						8-6-1		
390		10						8-6-2		502
400		20								503
410		30						8-6-3	granules	504
420		40				5Y4/2				505
430		50						8-6-4	granule clusters	506
440		60						8-6-5		507
450		70							granule clusters	508
		80								
		90								
		100								

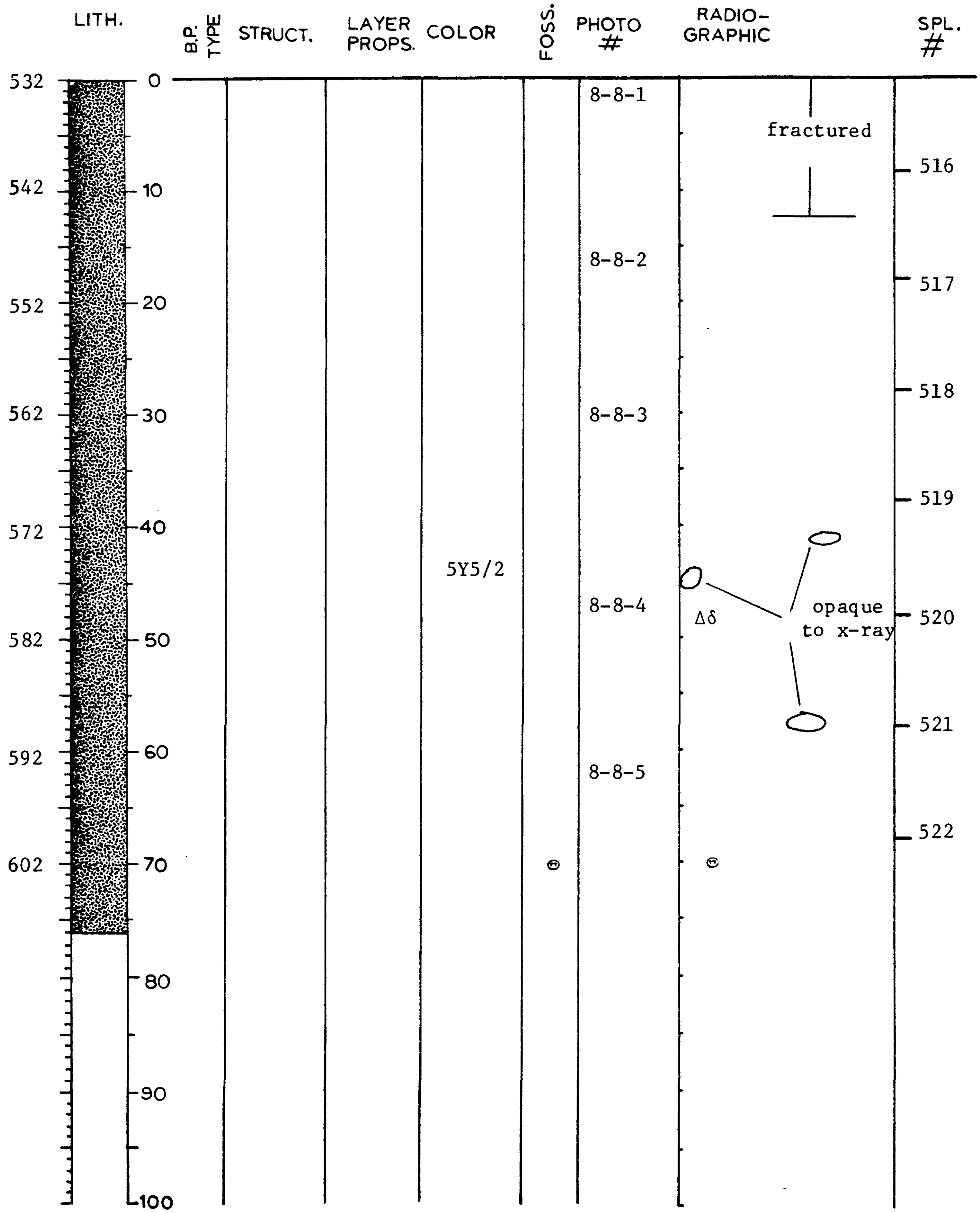
slight mottling throughout

HOLE 8 SLUG 7 DEPTH 456 cm. to 532 cm.

Depth		LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIOGRAPHIC	SPL. #
456	0							8-7-1		509
466	10							8-7-2		510
476	20								∝	511
486	30							8-7-3		512
496	40					5Y5/2		8-7-4		513
506	50								Δδ	514
516	60							8-7-5	granules Δδ	515
526	70								∝	
	80									
	90									
	100									

scattered mottling and bioturbation throughout

HOLE 8 SLUG 8 DEPTH 532 cm. to 608 cm.



bioturbation throughout

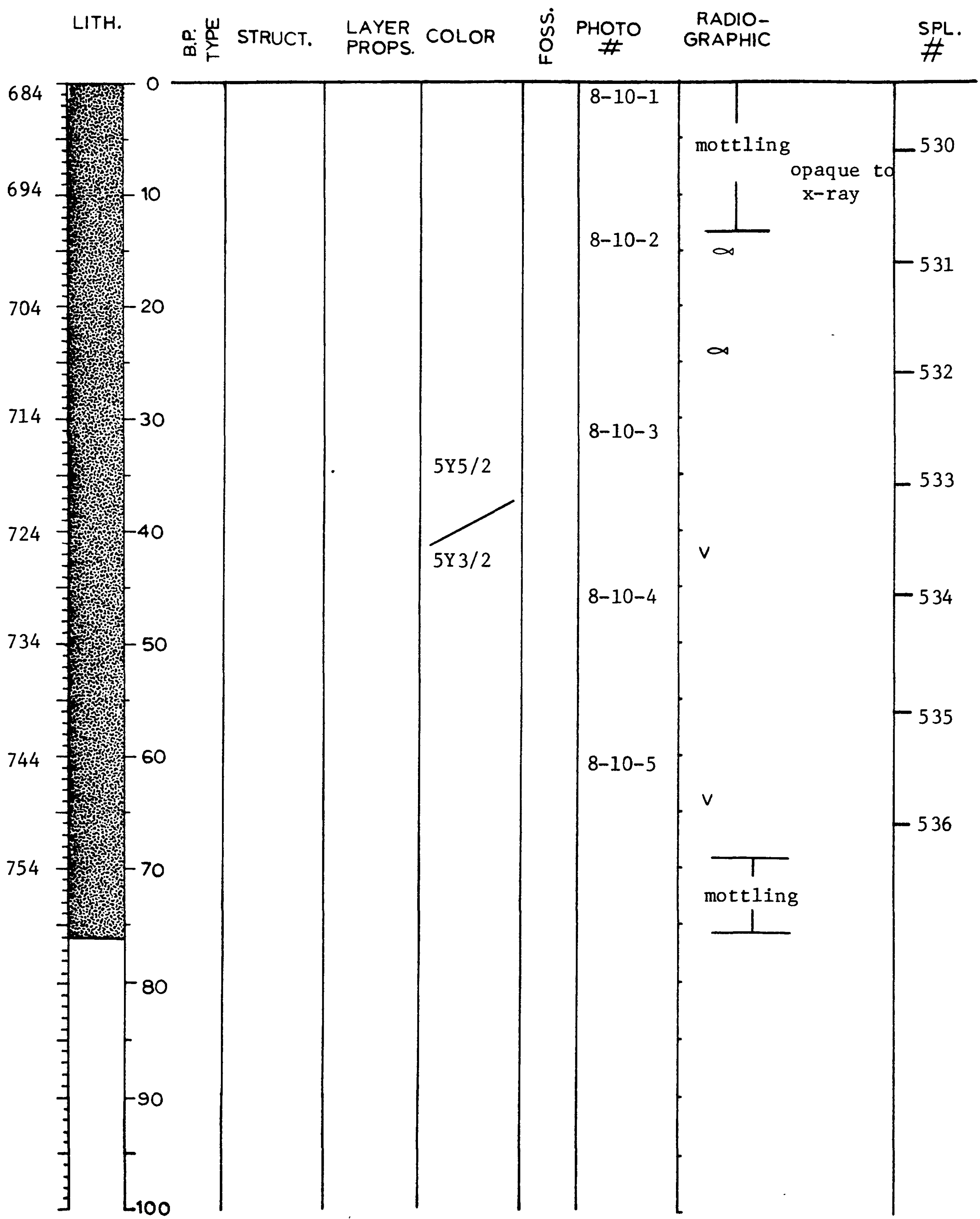
disseminated fish bones throughout

HOLE 8 SLUG 9 DEPTH 608 cm. to 684 cm.

LITH.		B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
608	0						8-9-1	mottled and possibly disturbed	
618	10								523
							8-9-2	Δδ fractures	
628	20								524
								Δδ	
638	30						8-9-3	Δδ	525
648	40				5Y4/2				526
							8-9-4		
658	50							v Δδ granules	527
668	60						8-9-5		528
								Δδ	
678	70								529
	80								
	90								
	100								

bioturbation throughout

HOLE 8 SLUG 10 DEPTH 684 cm. to 760 cm.



granules and bioturbation throughout

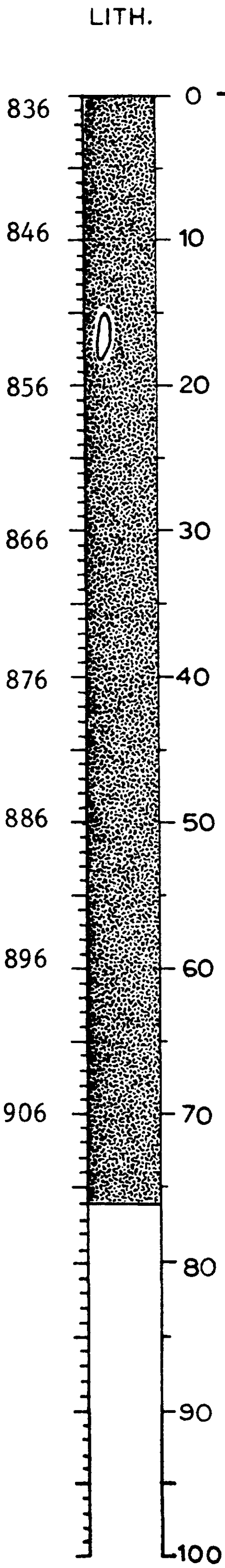
HOLE 8 SLUG 11 DEPTH 760 cm. to 836 cm.

Depth (cm)	Interval (cm)	LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIOGRAPHIC	SPL. #
760	0							8-11-1		
770	10									537
								8-11-2		
780	20									538
790	30							8-11-3		539
						5Y5/2				
800	40									540
								8-11-4	Δδ	
810	50									541
820	60									542
								8-11-5	mottling	
830	70									543
	80									
	90									
	100									

fractured in upper 18 cm

bioturbation throughout

HOLE 8 SLUG 12 DEPTH 836 cm. to 912 cm.

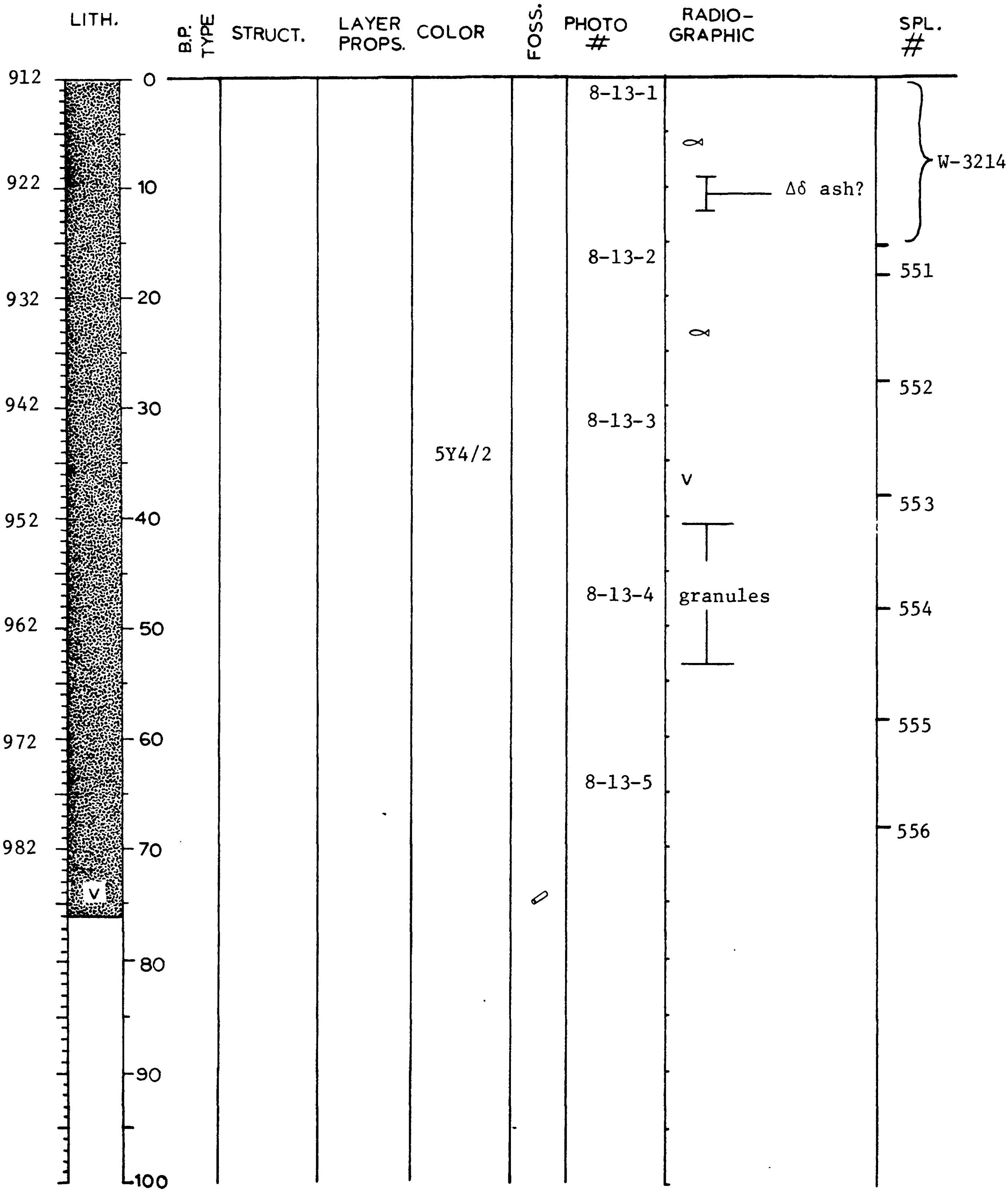


B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIOGRAPHIC	SPL. #
					8-12-1		544
							545
					8-12-2	iron concretions	
						Δδ	
						v	546
						mottle	
					8-12-3		
			5Y3/2				547
					8-12-4		548
							549
						scattered granules	
					8-12-5		550

longitudinal crack below 20 cm

bioturbation and disseminated granules throughout

HOLE 8 SLUG 13 DEPTH 912 cm. to 988 cm.



W-3214: 9,850 ± 250

verticle cracks above 69 cm

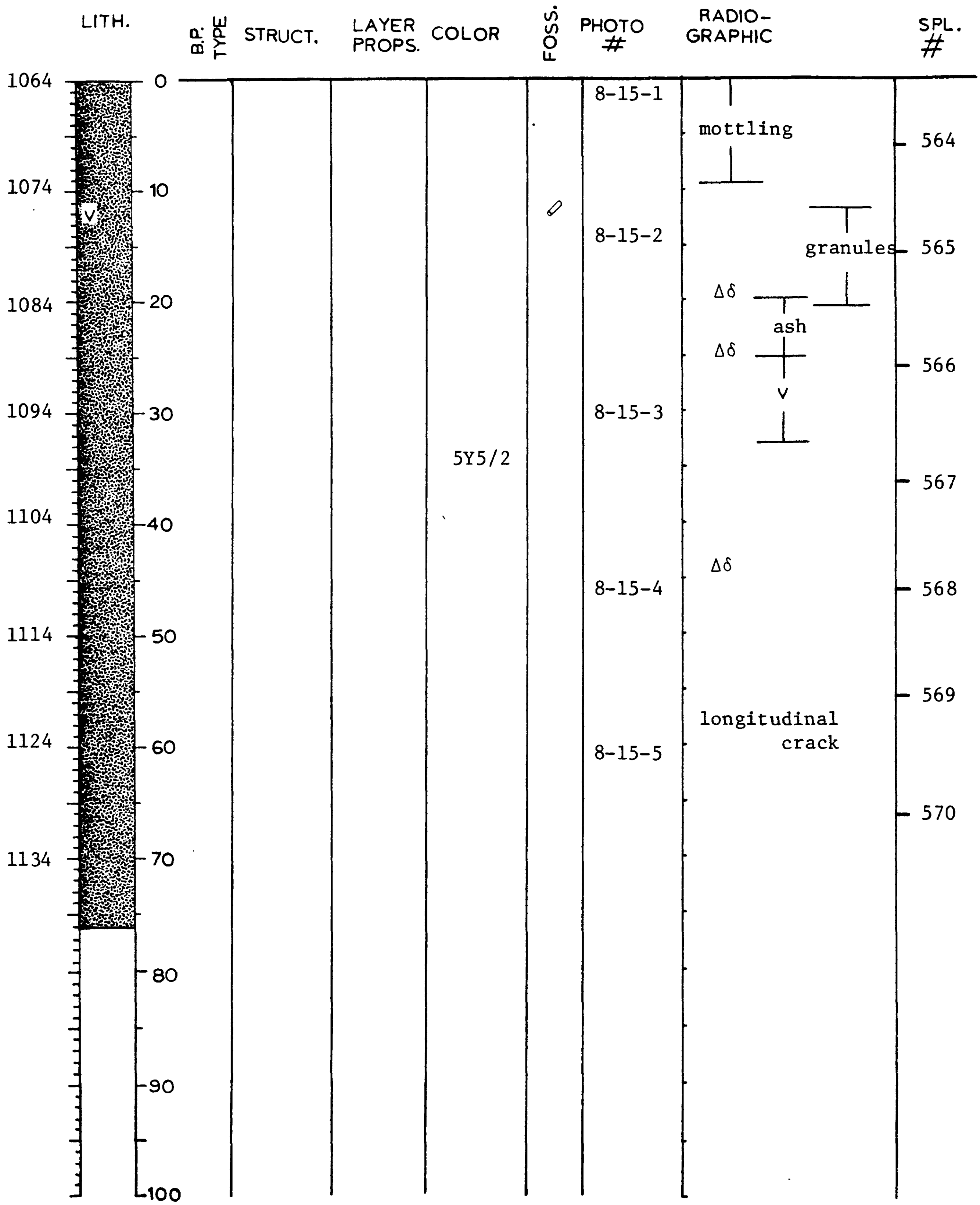
bioturbation throughout

HOLE 8 SLUG 14 DEPTH 988 cm. to 1064 cm.

LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIOGRAPHIC	SPL. #
988 — 0						8-14-1		
998 — 10								557
						8-14-2		
1008 — 20							longitudinal fracture	558
1018 — 30 V				5Y4/2		8-14-3		559
1028 — 40							mottle	560
1038 — 50						8-14-4	V Δδ ash?	561
1048 — 60						8-14-5	scraping mark	562
1058 — 70							V	563
— 80								
— 90								
— 100								

bioturbation throughout

HOLE 8 SLUG 15 DEPTH 1064 cm. to 1140 cm.

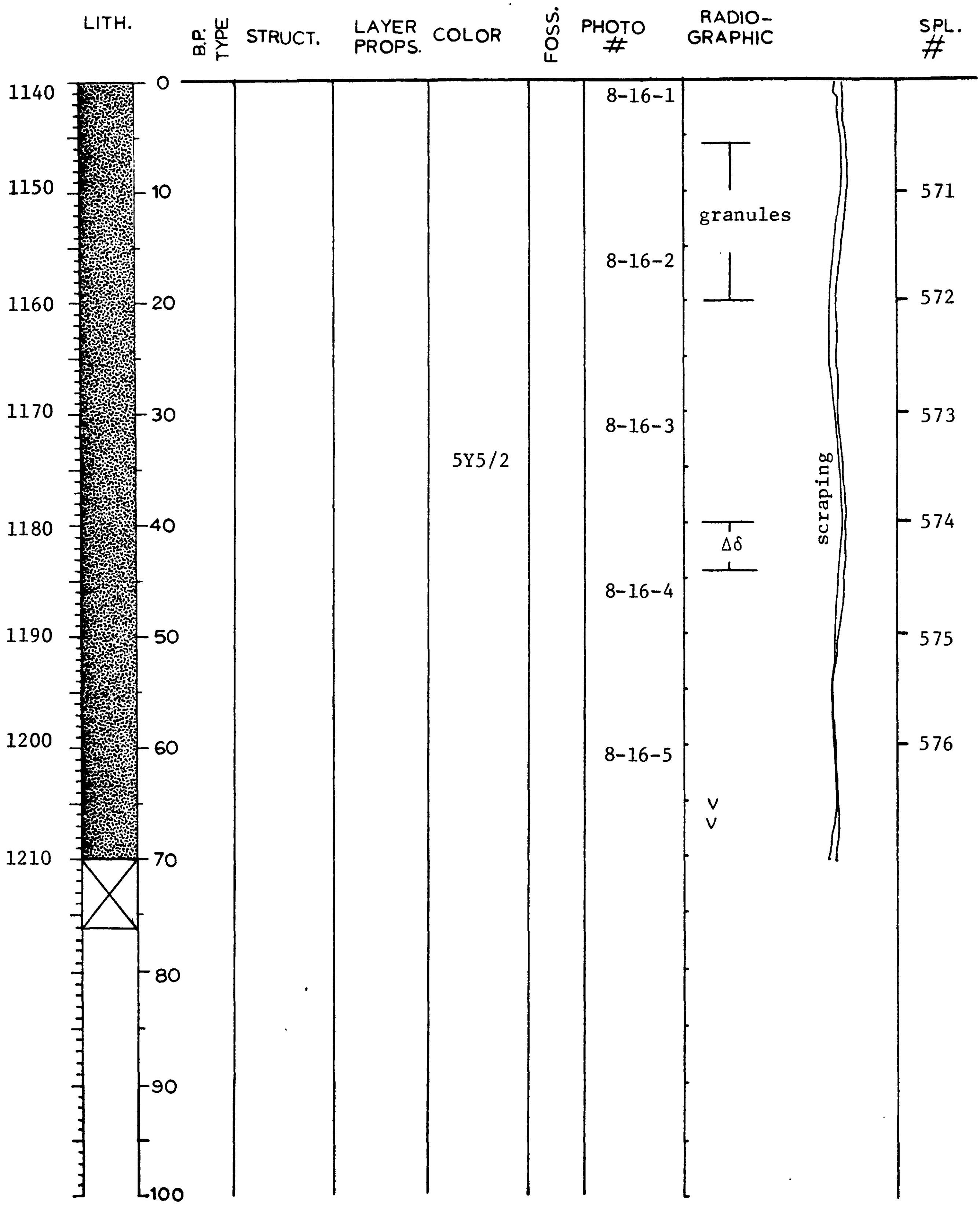


longitudinal crack upper 40 cm

bioturbation throughout (some w/ vivianite fillings)

disseminated fish bones throughout

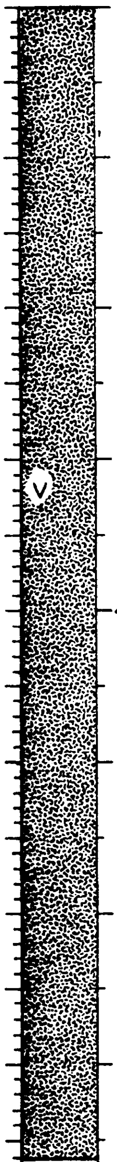
HOLE 8 SLUG 16 DEPTH 1140 cm. to 1216 cm.



longitudinal and verticle cracking above 50 cm
bioturbation and scattered mottling throughout

HOLE 8 SLUG 17 DEPTH 1216 cm. to 1292 cm.

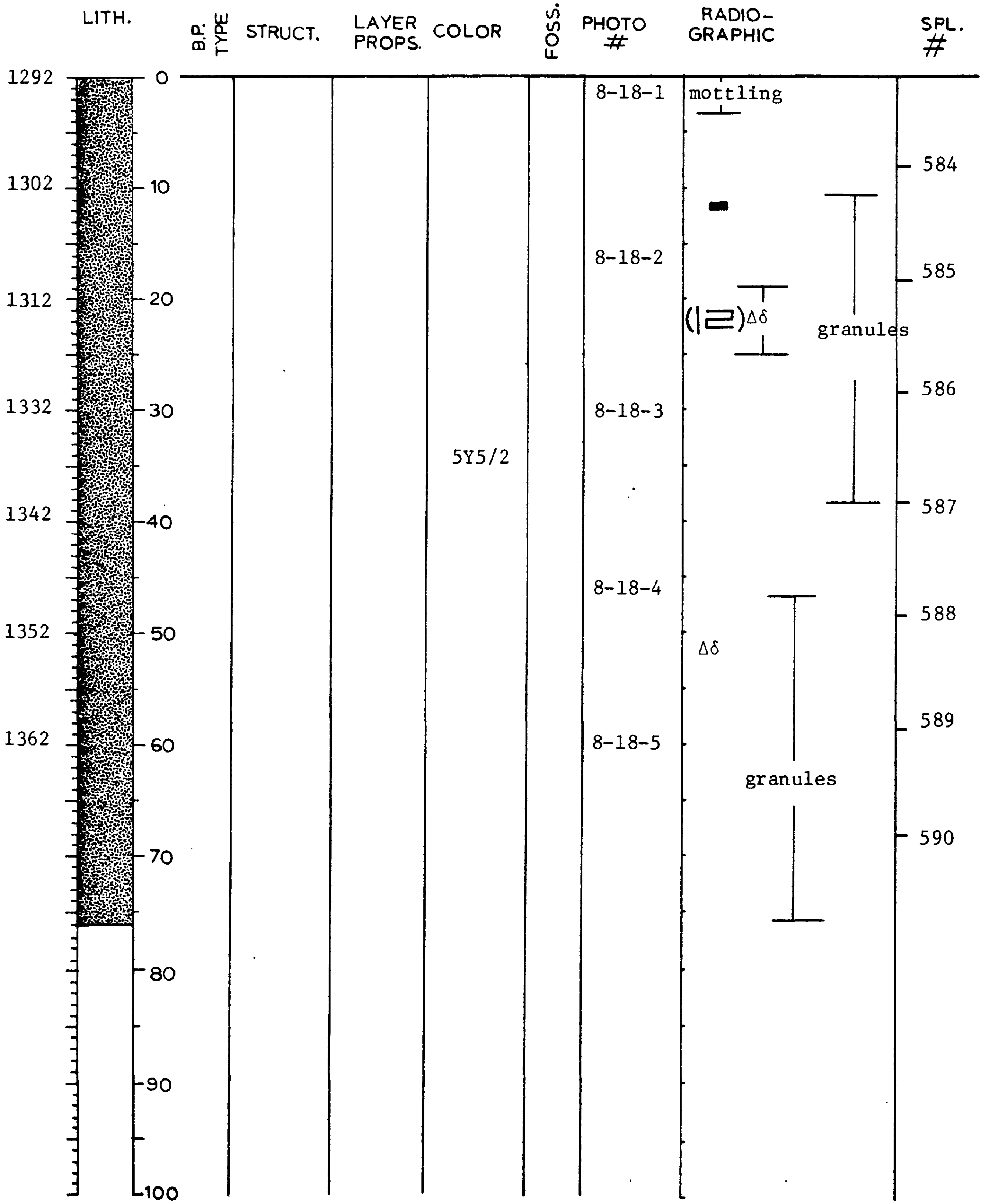
LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
1216 — 0						8-17-1	mottling	577
1226 — 10						8-17-2		578
1236 — 20								579
1246 — 30				5Y4/2		8-17-3		580
1256 — 40						8-17-4		581
1266 — 50								582
1276 — 60						8-17-5	granules	583
1286 — 70								
80								
90								
100								



upper 17 cm badly fractured

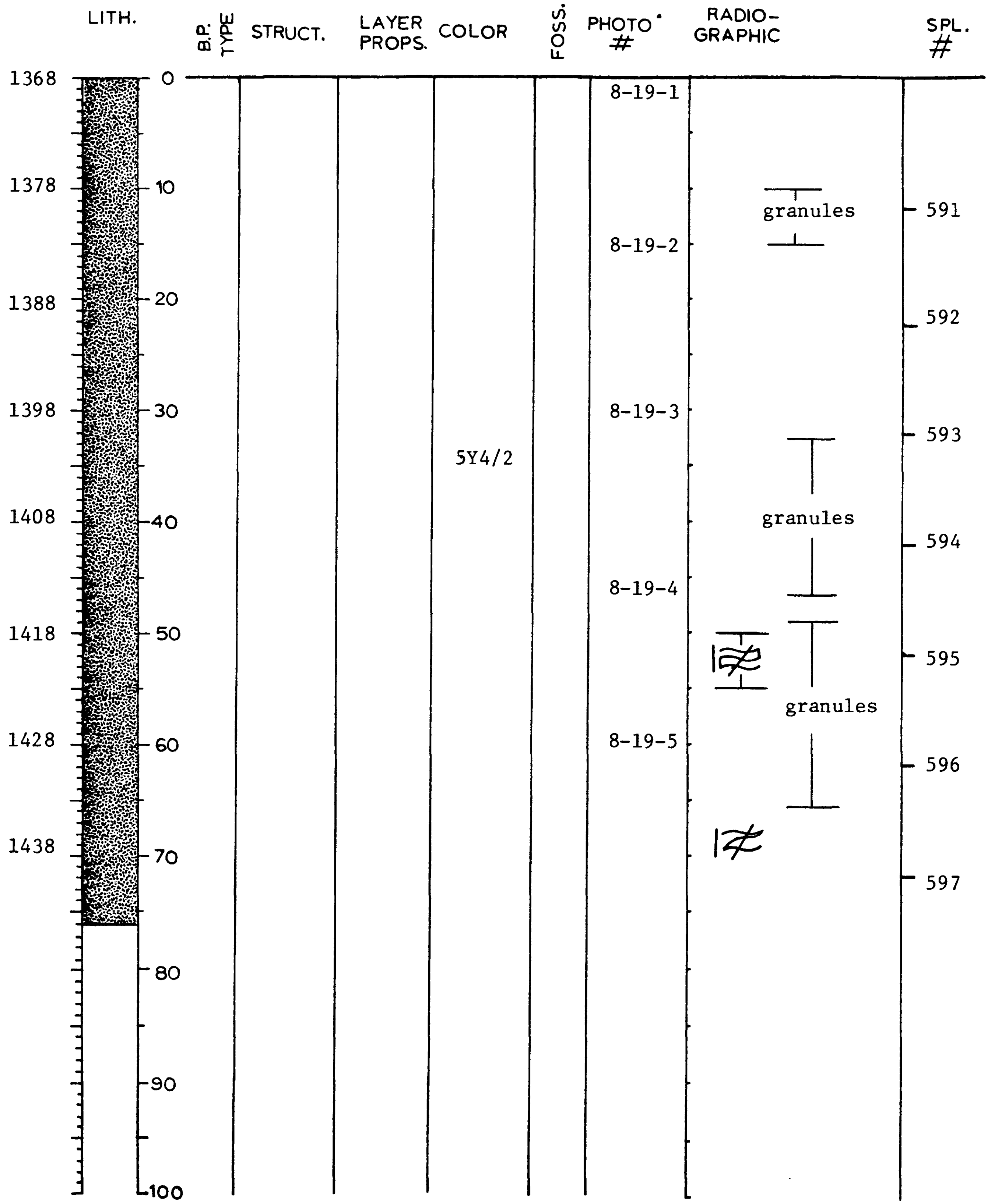
bioturbation throughout

HOLE 8 SLUG 18 DEPTH 1292 cm. to 1368 cm.



bioturbation and vertical cracks throughout

HOLE 8 SLUG 19 DEPTH 1368 cm. to 1444 cm.

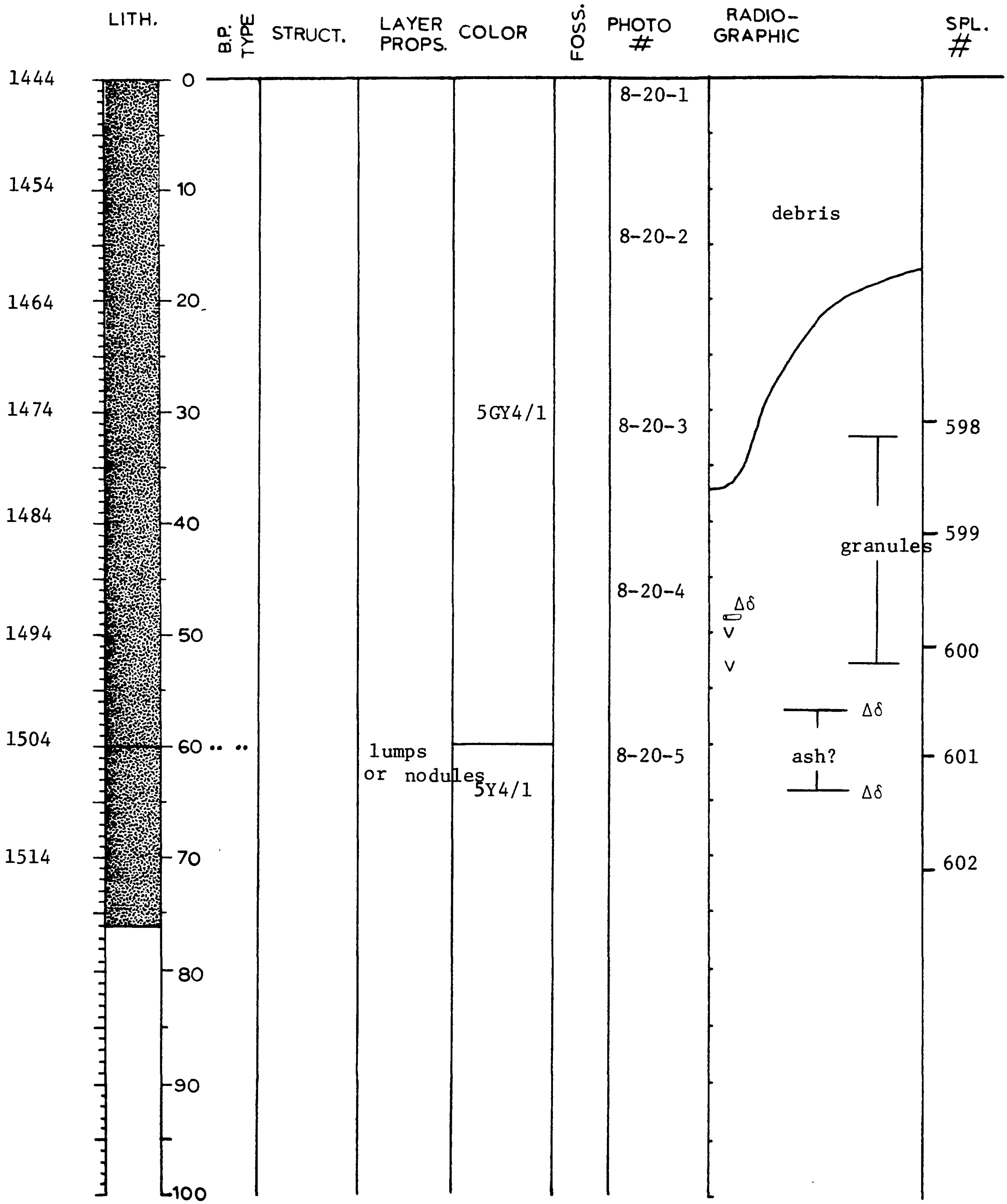


crumbly upper 10 cm and 47-50 cm

bioturbation throughout

disseminated fish bones throughout

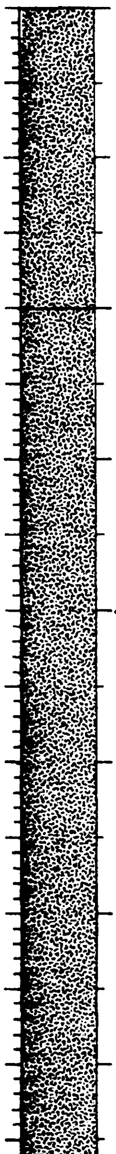
HOLE 8 SLUG 20 DEPTH 1444 cm. to 1520 cm.



bioturbation throughout

disseminated fish bones throughout

HOLE 8 SLUG 21 DEPTH 1520 cm. to 1596 cm.



Depth (cm)	Interval (cm)	B.P. Type	Struct.	Layer Props.	Color	Foss.	Photo #	Radiographic	Spl. #
1520	0						8-21-1		
					5Y4/1			granules mottling	
1530	10							granules	
							8-21-2		
1540	20	•• ••		lumps or nodules				v granules	
									603
1550	30						8-21-3	v	
									604
1560	40							Δδ	605
							8-21-4		
1570	50				5Y4/2				
								granules	606
1580	60						8-21-5		
									607
1590	70								
	80								
	90								
	100								

fracturing from 0-43 cm and 69-77 cm

bioturbation throughout

disseminated fish bones throughout

HOLE 8 SLUG 22 DEPTH 1596 cm. to 1672 cm.

		LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
1596	0							8-22-1		
1606	10									
										608
								8-22-2		
1616	20									
									Δδ	609
1626	30					5Y3/2		8-22-3		
										610
1636	40									
										611
								8-22-4		
1646	50								granules	
										612
1656	60							8-22-5		
									granules	613
1666	70									
										614
	80									
	90									
	100									

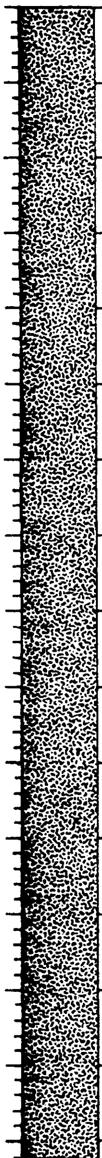
verticle cracking 0-47 cm

slight mottling and bioturbation throughout

vivianite (?) veins 42-64 cm

disseminated fish bones throughout

HOLE 8 SLUG 23 DEPTH 1672 cm. to 1748 cm.



Depth (cm)	LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
1672	0						8-23-1	◉	
1682	10							mottle	
							8-23-2		
									615
1692	20								
									616
1702	30						8-23-3		
					(5Y4/2) 5B5/1				
									617
1712	40								
							8-23-4		
									618
1722	50								
									619
1732	60						8-23-5		
									620
1742	70								
	80								
	90								
	100								

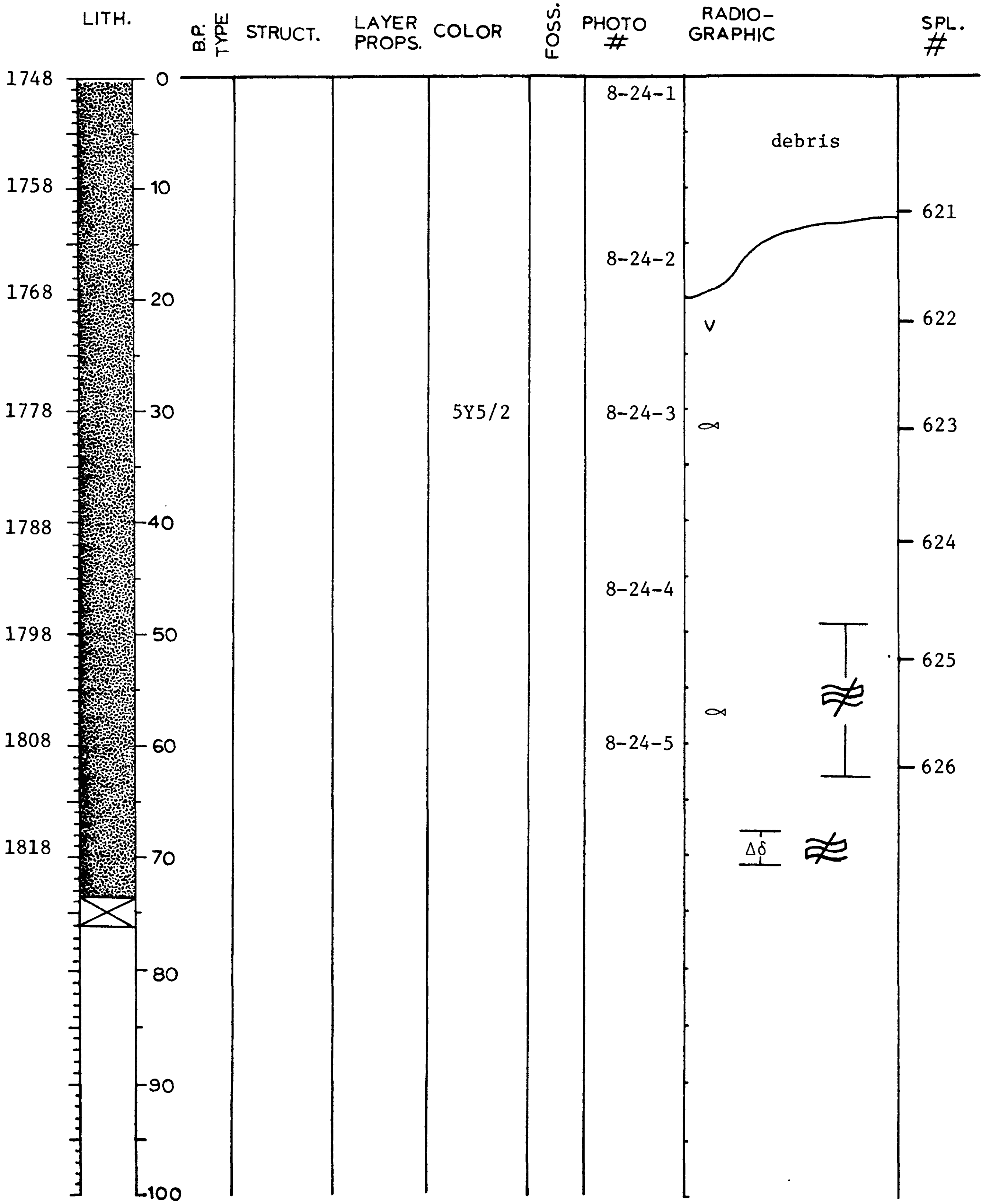
mottling is probably unoxidized mud

badly fractured spl.

mottling, granule clusters, disseminated vivianite and bioturbation throughout

disseminated fish bones throughout

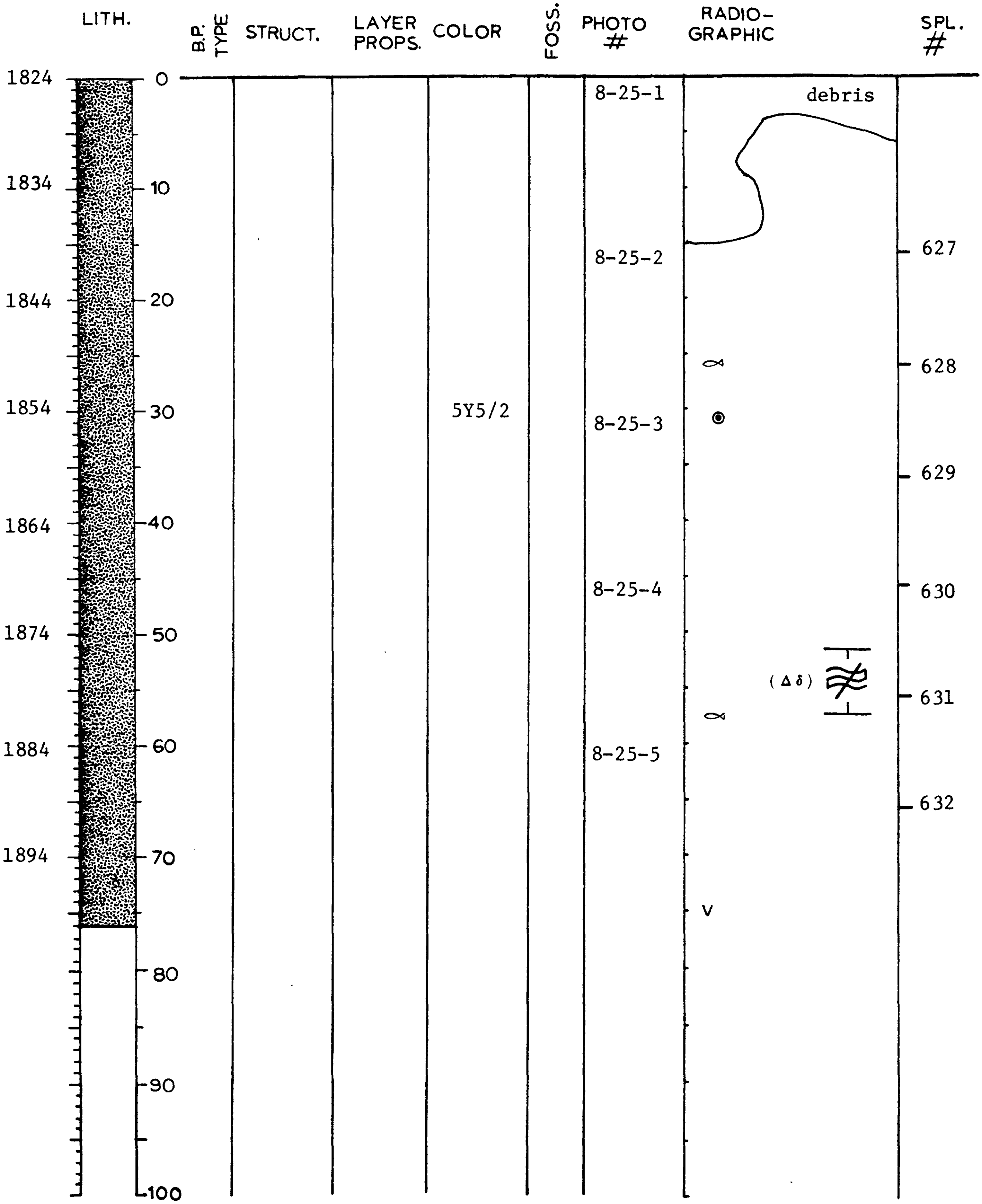
HOLE 8 SLUG 24 DEPTH 1748 cm. to 1824 cm.



0-19 cm distrubed and mottled

bioturbation throughout

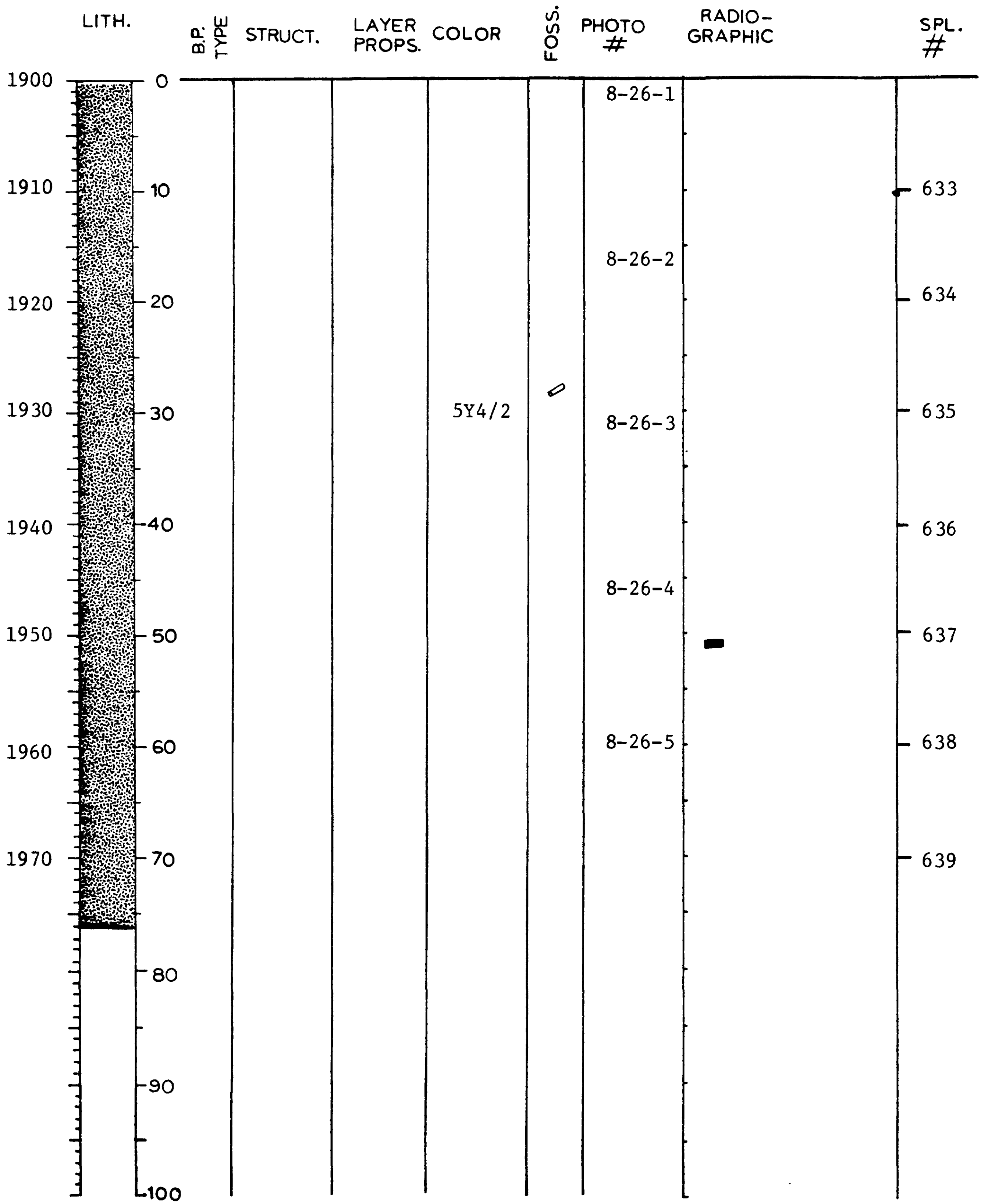
HOLE 8 SLUG 25 DEPTH 1824 cm. to 1900 cm.



5G5/1 unoxidized color

bioturbation throughout

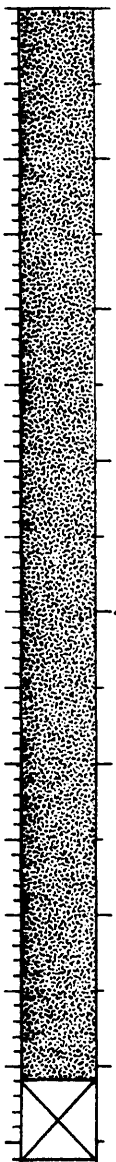
HOLE 8 SLUG 26 DEPTH 1900 cm. to 1976 cm.



badly fractured when slice was taken, exceptionally sticky

mottling, bioturbation, and granules throughout

HOLE 8 SLUG 27 DEPTH 1976 cm. to 2052 cm.



Depth (cm)	Scale	LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
1976	0							8-27-1	ash	
									Δδ	
1986	10									640
								8-27-2		
1996	20								granules	
										641
2006	30					(5Y5/2) 5B5/1		8-27-3		
										642
2016	40									
										643
								8-27-4		
2026	50									
										644
2036	60							8-27-5		
										645
2046	70									
	80									
	90									
	100									

badly fractured

mottling, granules and bioturbation throughout

Appendix B

X-ray Radiographs


TOP
CLEAR LAKE 8-01
BOTTOM


TOP
CLEAR LAKE 8-02
BOTTOM


TOP
CLEAR LAKE 8-03
BOTTOM


BOTTOM
TOP
CLEAR LAKE 8-05


BOTTOM
TOP
CLEAR LAKE 8-07


BOTTOM
TOP
CLEAR LAKE 8-04


BOTTOM
TOP
CLEAR LAKE 8-06


BOTTOM
TOP CLEAR LAKE 8-09


BOTTOM
TOP CLEAR LAKE 8-11


BOTTOM
TOP CLEAR LAKE 8-08


TOP CLEAR LAKE 8-10


TOP
CLEAR LAKE 8 – 13


BOTTOM
TOP
CLEAR LAKE 8 – 15


TOP
CLEAR LAKE 8 – 12


TOP
CLEAR LAKE 8 – 14


TOP
CLEAR LAKE 8-16
BOTTOM


TOP
CLEAR LAKE 8-17
BOTTOM


TOP
CLEAR LAKE 8-18
BOTTOM


TOP
CLEAR LAKE 8-19
BOTTOM


BOTTOM
TOP CLEAR LAKE 8-21


TOP CLEAR LAKE 8-23


TOP CLEAR LAKE 8-20


BOTTOM
TOP CLEAR LAKE 8-22


TOP
CLEAR LAKE 8-24
BOTTOM


TOP
CLEAR LAKE 8-25
BOTTOM


TOP
CLEAR LAKE 8-26


TOP
CLEAR LAKE 8-27
BOTTOM