

U.S. Geological Survey

OPEN FILE REPORT

Preliminary description and interpretation of
cores and radiographs from Clear Lake, Lake County, California: Core 5

by

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1975

This report is preliminary and has not been edited or
reviewed for conformity with Geological Survey standards
Report No. 75-381

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 km² 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 115.21 m (Table 1).

SUMMARY OF DATA

Core 5 is from near the south shore of the main body of Clear Lake (fig. 1), and was taken on 25-26 October 1973. Depth of water at the site is 7.6m. The core is 22.56 m long. Coring was not advanced further

because strong storm generated waves broke the well casing. The sediments in Core 5 consist of olive gray to dark olive gray (5Y4/2 to 5Y3/2) mud with seven interbedded volcanic ashes (fig. 2). The colors of the 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 greenish gray or dark greenish gray (5GY6/1 or 5BG4/1). No zones of deformed sediments were found in the core, because bioturbation of the sediments is very extensive throughout, and probably completely obscured or rendered uninterpretable any such sedimentologic features.

One radiocarbon age determination was made on sediments from Core 5. Meyer Rubin of the U.S. Geological Survey performed the analysis on a highly organic-rich zone from slug 24 (fig. 2). The date (W-3220) is $24,080 \pm 1,000$ yrs. B.P. This date represents a sedimentation rate of 0.90 mm yr^{-1} for the core.

Of importance is the preserved record of volcanic eruptions in this core. Seven ash beds or probable ash beds are preserved in Core 5 (fig. 2). Five of the seven ash beds in Core 5 are tentatively correlated with ash beds in Core 7 (see fig. 1 for location of Core 7). The uppermost ash in Core 5 is correlated with the second ash in Core 7; the ash in slug 16, Core 5 is correlated with ash in slug 17, Core 7; the upper ash in slug 22, Core 5 is correlated with the ash in slug 21, Core 7; and the ashes in slug 23, Core 5 are correlated with the two ashes in slug 23, Core 7. Core 7 was chosen for correlation because it contains abundant ash and peat beds (Sims and Rymer, 1975). Many of the peat beds in Core 7 have been dated by the ^{14}C method, thus allowing age correlations as well.

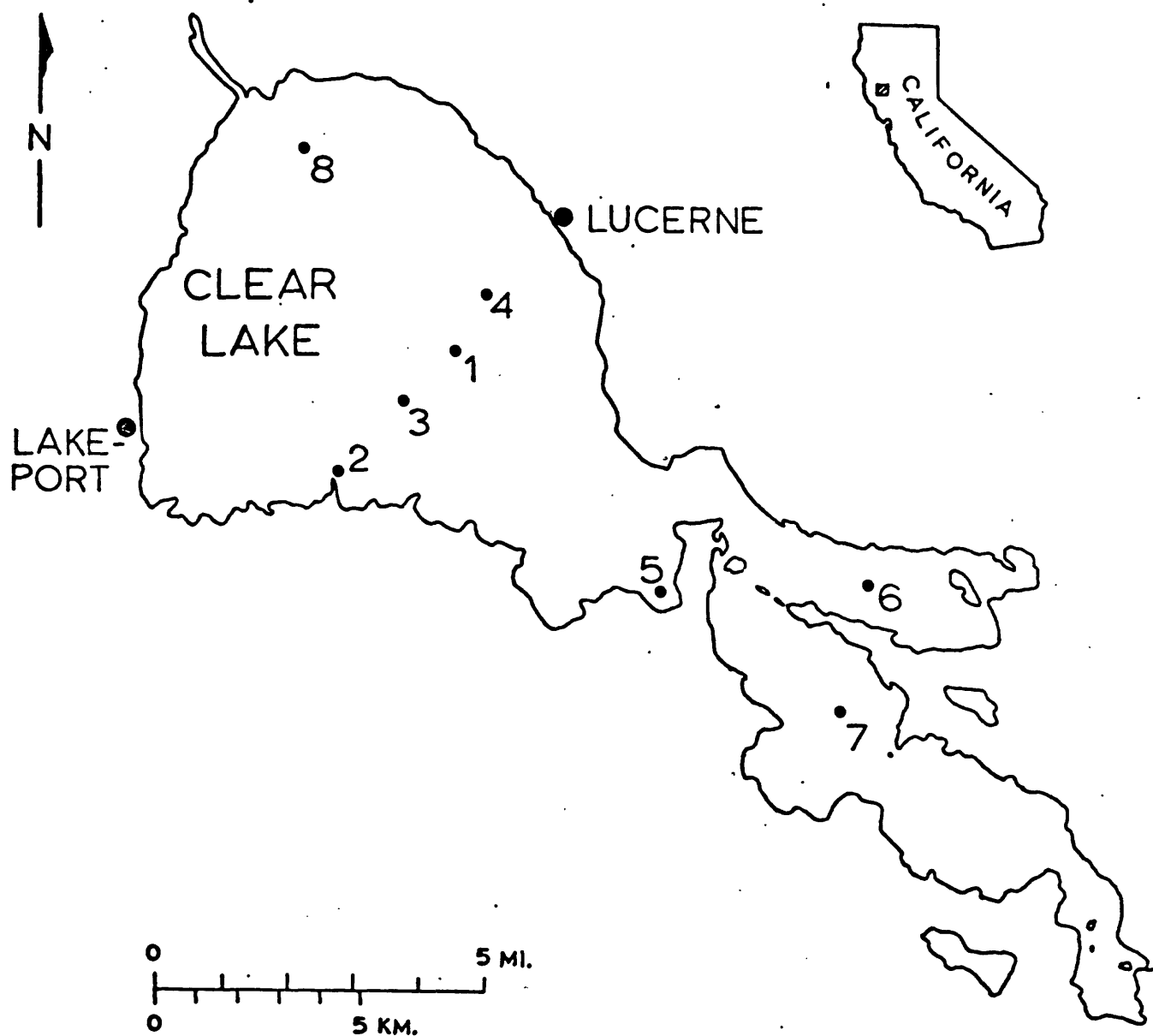


Figure 1. Map showing location of Core 5 in Clear Lake, California. Other numbered core sites in the lake are the subjects of separate reports.

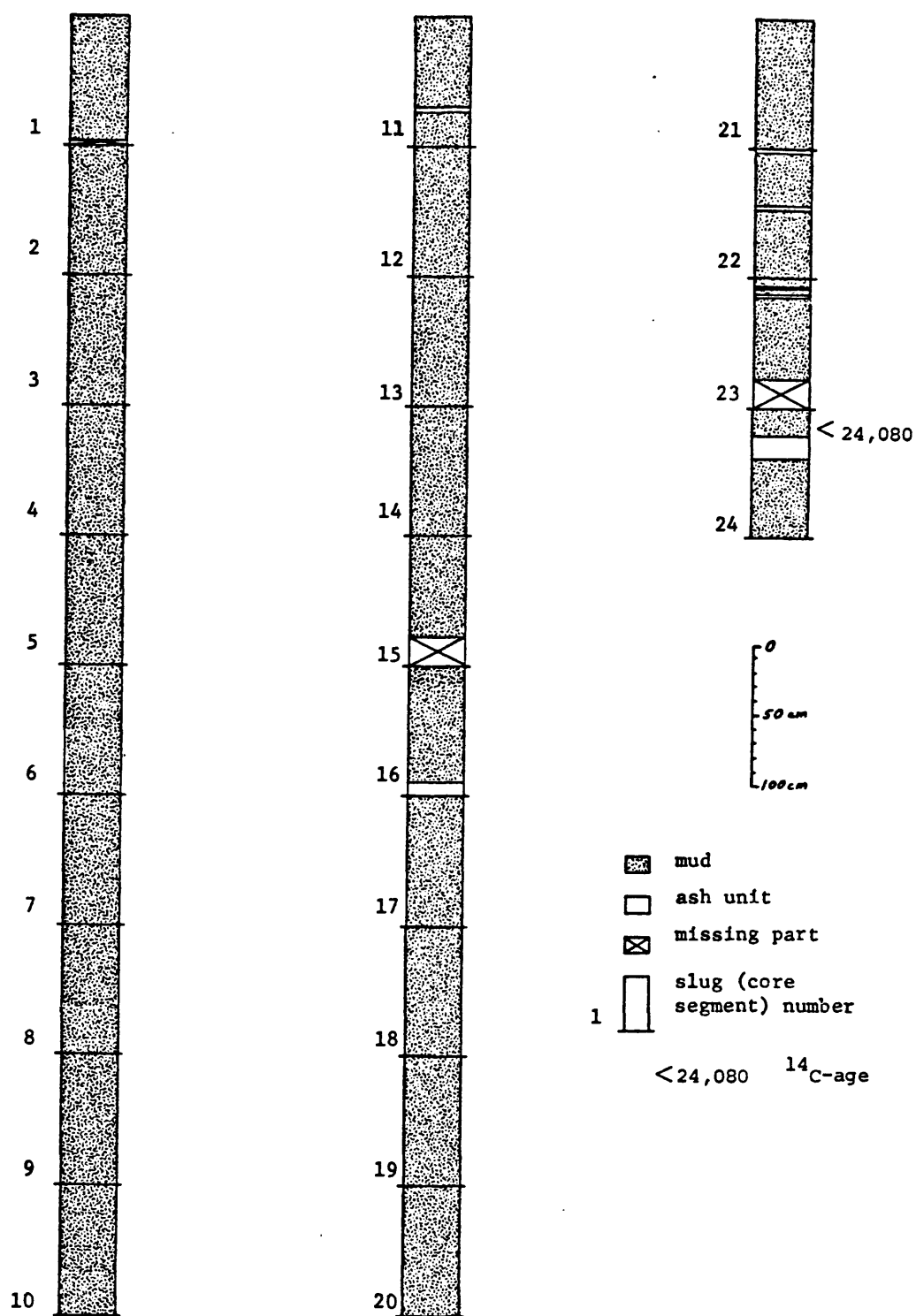


Figure 2. Generalized lithology of sediments from Core 5, Clear Lake, California.

A plot of ^{14}C -age and correlated ^{14}C -age versus depth (fig. 3) shows the consistency of the age date from Core 5 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 $y = 11.29x + 141.02$ and has a correlation coefficient of $r = 0.996$. 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 from Clear Lake, California.

<u>Core</u>	<u>Length (m)</u>	<u>Recovery (%)</u>
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

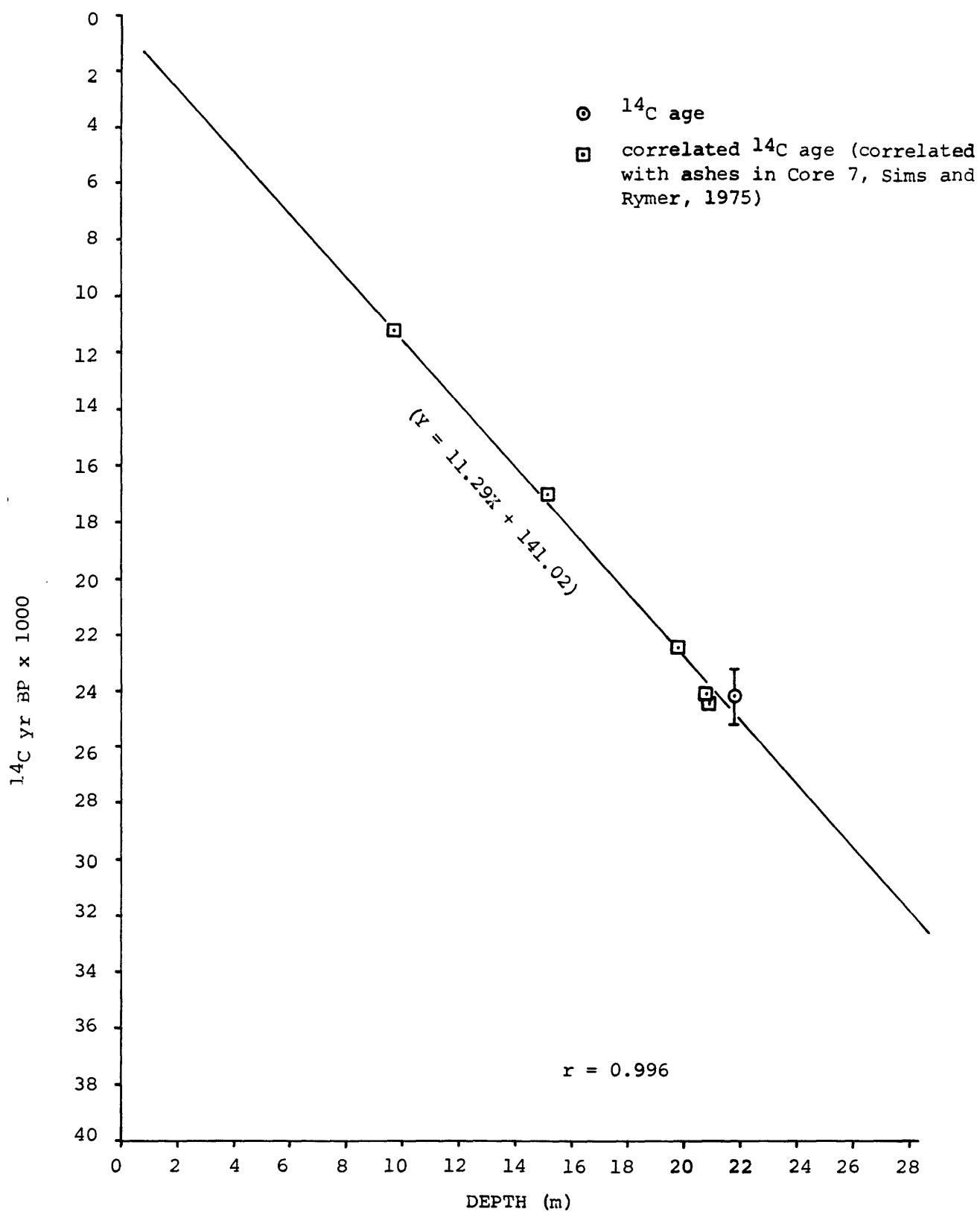


Figure 3. Plot of ^{14}C -age determination and correlated ^{14}C -age determinations and depth in Clear Lake, Core 5. The line $y = 11.29x + 141.02$ is fitted to the data by linear regression. The correlation coefficient (r) is 0.996. Error limits on the ^{14}C -age from Core 5 shown by vertical bar.

METHOD OF STUDY

Core 5 was obtained using Shelby and Ostenberg samplers 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 2.5 to 5 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 original.

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:

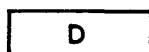
John D. Sims
U.S. Geological Survey
Earthquake Tectonics Branch
345 Middlefield Road
Menlo Park, California 94025

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

	ash		clayey silt
	clay		silty clay
	silt		clayey sand
	sand		sandy mud
	gravel		sandy silt
	peat		sandy gravel
	mud		clayey peat
	silty sand		silty peat



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.





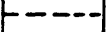




interlaminated strata;
dominant lithology on left
(in this example clayey peat and mud)

HOLE — SLUG — DEPTH — cm. to — cm. .





LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO- GRAPHIC	SAMPLE #
0								
10								
20								
30								
40								
50								
60								
70								
80								
90								


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 > 1.0)
	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:

$\frac{10Y\ 5/4}{5YR\ 5/4}$

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.

$10Y\ 5/4 \mid 5YR\ 5/4$

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 5. 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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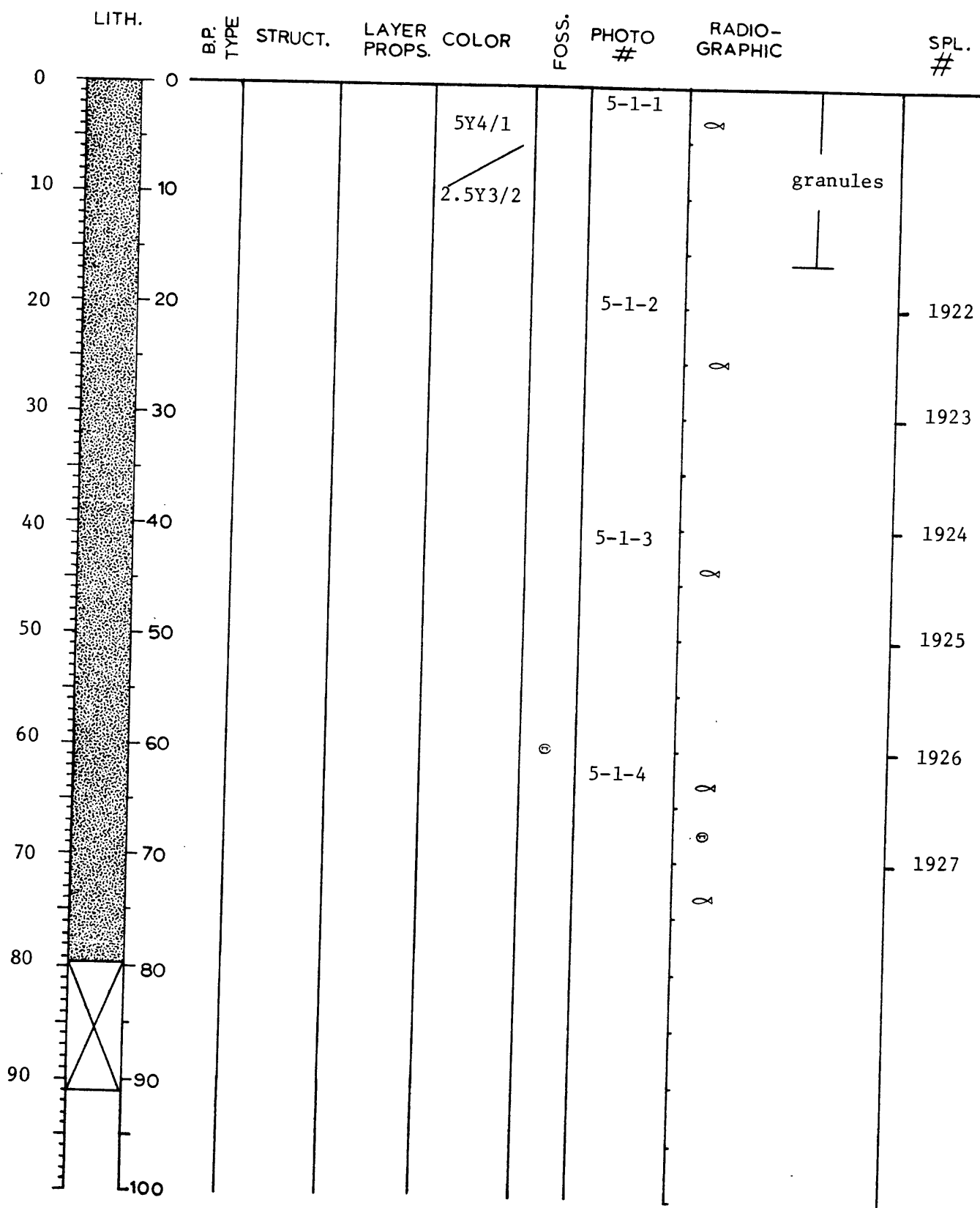
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- Sims, J.D. and Rymer, M.J., 1974, Gaseous springs in Clear Lake, California, and the structural control of the lake basin: Geol. Soc. America, Abstracts with Programs, v. 6, no. 3, p. 254.
- Sims, J.D. and Rymer, M.J., 1975, Preliminary description and interpretation of cores and radiographs from Clear Lake, Lake County, California: Core 7, Open File Report No. 75-144, 21p.

Appendix A

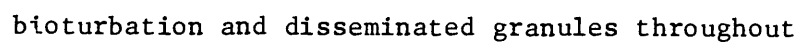
Graphical Logs

HOLE 5 SLUG 1 DEPTH 0 cm. to 91 cm.

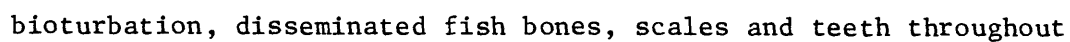


disseminated granules and bioturbation throughout

HOLE 5 SLUG 2 DEPTH 91 cm. to 183 cm.



HOLE 5 SLUG 3 DEPTH 183 cm. to 274 cm.



HOLE 5 SLUG 4 DEPTH 274 cm. to 366 cm.

LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO- GRAPHIC	SPL. #
274	0					5-4-1		
284	10							
294	20					5-4-2		2098
304	30							2099
314	40			5Y4/1		5-4-3		2100
324	50							2101
334	60					5-4-4		2102
344	70							2103
354	80							2104
364	90							
	100							

bioturbation, disseminated granules, fish bones and scales throughout
oxidation along fractures

HOLE 5 SLUG 5 DEPTH 366 cm. to 457 cm.

LITH.	BR. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
366	0					5-5-1		
376	10				λ			
386	20					5-5-2		
396	30			5Y4/1	⊙			
406	40					5-5-3		
416	50							
426	60					5-5-4		
436	70							1928
446	80							
456	90							1929
	100							

NO RADIOGRAPH

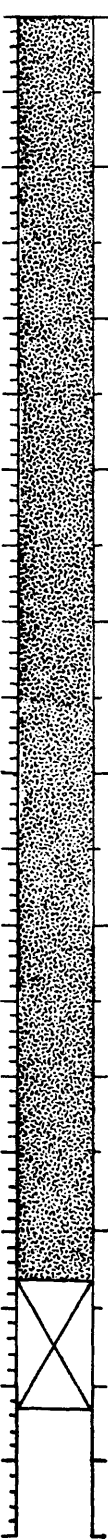
bioturbation and disseminated granules throughout
oxidation zone along fractures

HOLE 5 SLUG 6 DEPTH 457 cm. to 549 cm.

LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO- GRAPHIC	SPL. #
457						5-6-1		
467				5GY4/1 5Y4/1			①	1930
477					◆	5-6-2	v	1931
487								1932
497						5-6-3		1933
507								1934
517						5-6-4		1935
527								1936
537								1937
547								

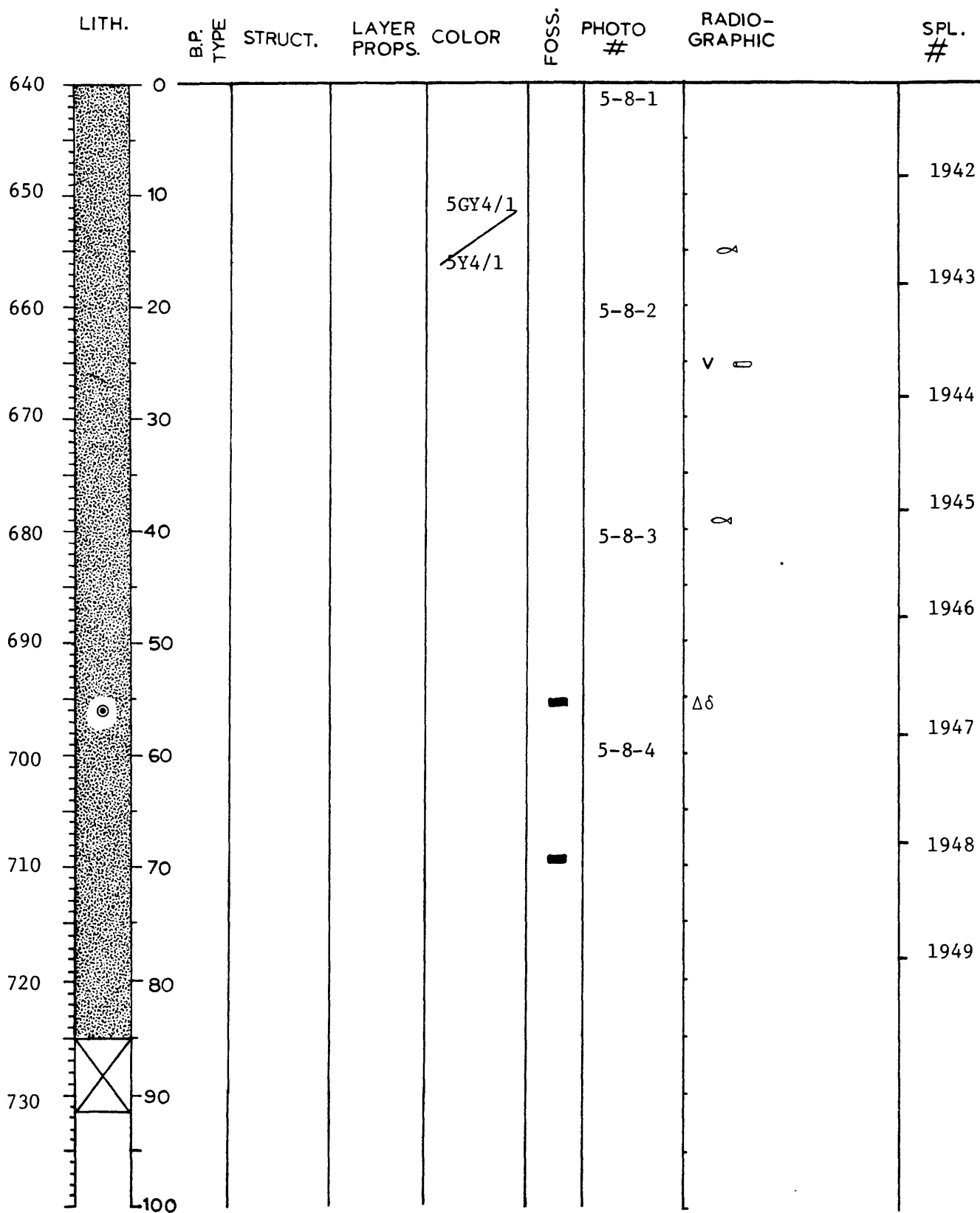
bioturbation and disseminated granules throughout
fish bones throughout

HOLE 5 SLUG 7 DEPTH 549 cm. to 640 cm.

	LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO- GRAPHIC	SPL. #
549		0					5-7-1		
559		10			5GY4/1 /				
569		20					5-7-2		
579		30							
589		40					5-7-3		
599		50							1938
609		60					5-7-4		1939
619		70							1940
629		80							1941
639		90							
		100							

bioturbation and disseminated granules throughout
 fish bones throughout
 oxidation along fractures

HOLE 5 SLUG 8 DEPTH 640 cm. to 732 cm.



bioturbation, disseminated granules and disseminated fish bones throughout

HOLE 5 SLUG 9 DEPTH 732 cm. to 823 cm.

LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
732	0					5-9-1		
				5GY4/1				1950
742	10			5Y4/1				1951
752	20					5-9-2		1952
762	30							1953
772	40					5-9-3		1954
782	50				■			1955
792	60				■	5-9-4		1956
802	70						v	1957
812	80				⊙			
822	90							
	100							

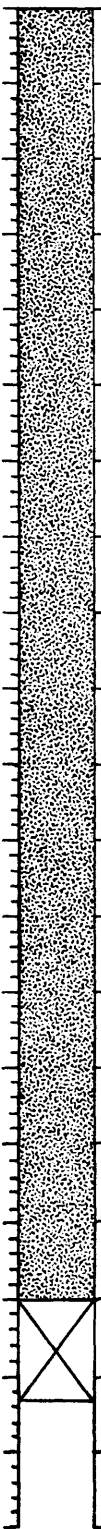


bioturbation, disseminated fish bones and scales throughout

HOLE 5 SLUG 10 DEPTH 823 cm. to 914 cm.

[illegible]

bioturbation, disseminated fish bones and scales throughout

HOLE 5 SLUG 11 DEPTH 914 cm. to 1006 cm.

LITH.	DEPTH	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
	0					5-11-1		1967
	10			5GY4/1				1968
	20			5Y4/1		5-11-2		1969
	30							1970
	40					5-11-3		1971
	50							1972
	60					5-11-4	 (Δδ) ash? (Δδ)	1973
	70							1974
	80							
	90							

bioturbation, disseminated granules, and disseminated fish bones and scales throughout

oxidation along fractures and edges

HOLE 5 SLUG 12 DEPTH 1006 cm. to 1097 cm.

LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO- GRAPHIC	SPL. #
1006						5-12-1		
1016				5Y3/1				2003
1026						5-12-2		2004
1036								2005
1046						5-12-3	v	2006
1056								2007
1066						5-12-4		2008
1076								2009
1086							v	
1096								
1106								

heavy bioturbation, disseminated granules, fish bones and scales throughout

HOLE 5 SLUG 13 DEPTH 1097 cm. to 1189 cm.

LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO- GRAPHIC	SPL. #
1097	0					5-13-1		
1107	10						v pebble pebble pebble pebble	1988
1117	20					5-13-2		1989
1127	30						pebble	1990
1137	40					5-13-3	pebble pebble	1991
1147	50				ø			1992
1157	60					5-13-4		1993
1167	70							1994
1177	80						pebble pebble	
1187	90							
	100							

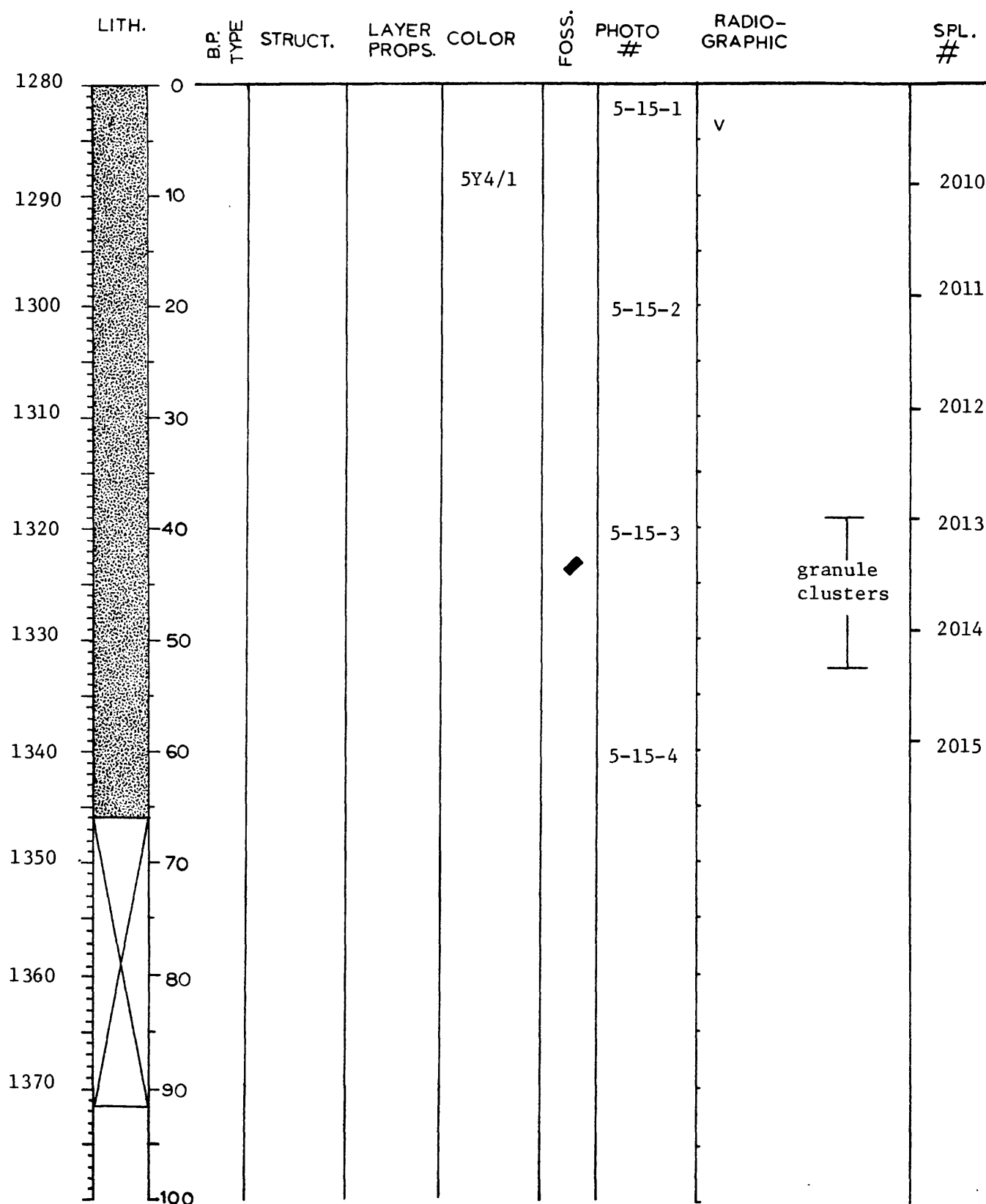
bioturbation, disseminated granules, fish bones and scales throughout

HOLE 5 SLUG 14 DEPTH 1189 cm. to 1280 cm.

LITH.	BP. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO-GRAPHIC	SPL. #
1189	0					5-14-1	v	
1199	10			5Y4/1			o	1995
1209	20					5-14-2		1996
1219	30				o		█	1997
1229	40				█	5-14-3	v	1998
1239	50						o	1999
1249	60					5-14-4	█ z granules	2000
1259	70						█	2001
1269	80							2002
1279	90							
	100							

bioturbation and disseminated granule clusters throughout

HOLE 5 SLUG 15 DEPTH 1280 cm. to 1372 cm.



bioturbation throughout
disseminated fish bones throughout

HOLE 5 SLUG 16 DEPTH 1433 cm. to 1524 cm.

[illegible]

heavy bioturbation throughout

30-72 cm: cracks containing drillers mud

HOLE 5 SLUG 17 DEPTH 1524 cm. to 1615 cm.

LITH.	B.P. TYPE	STRUCT.	LAYER PROPS.	COLOR	FOSS.	PHOTO #	RADIO- GRAPHIC	SPL. #
1524	0					5-17-1		
				5Y4/2			v	2024
1534	10							2025
						5-17-2	o	2026
1544	20							2027
						5-17-3		2028
1554	30							2029
						5-17-4		2030
1564	40							2031
1574	50							
1584	60							
1594	70							
1604	80							
1614	90							
	100							

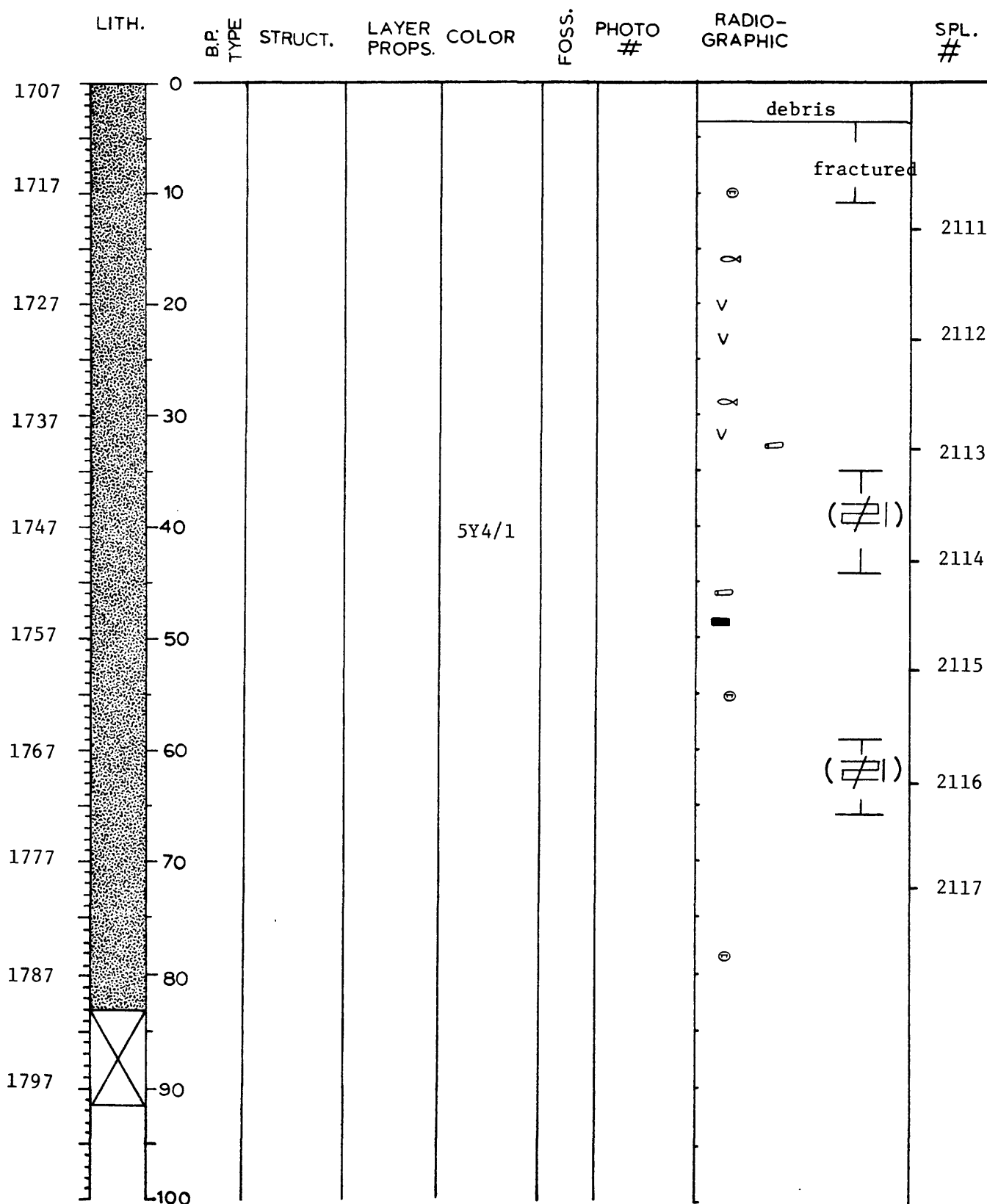
bioturbation throughout

3" Ostenberg
HOLE 5 SLUG 18 DEPTH 1615 cm. to 1707 cm.

scattered oxidation along fractures

3" Ostenberg

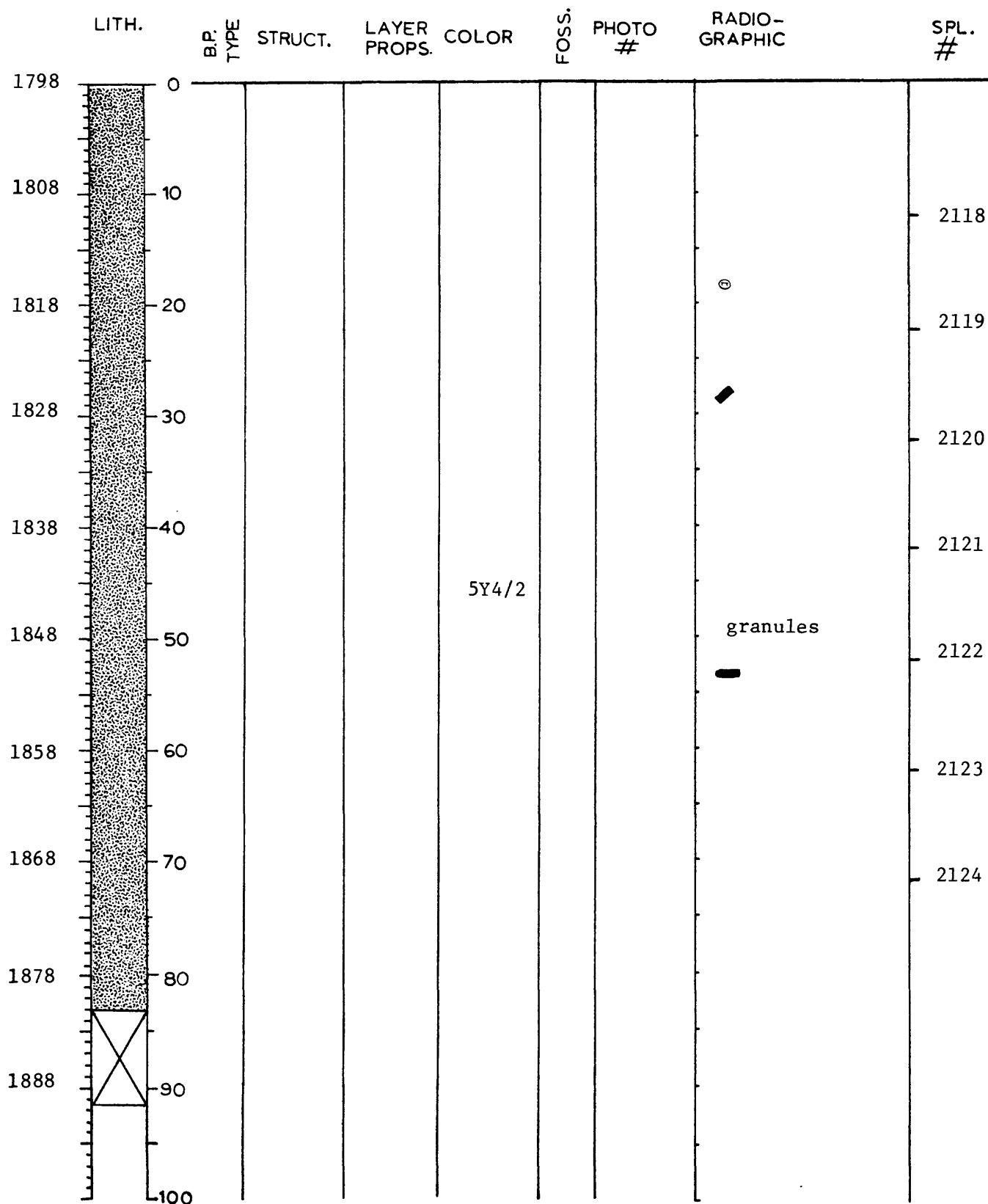
HOLE 5 SLUG 19 DEPTH 1707 cm. to 1798 cm.



granules, bioturbation, and scattered vivianite throughout
fish bones throughout

3" Ostenberg

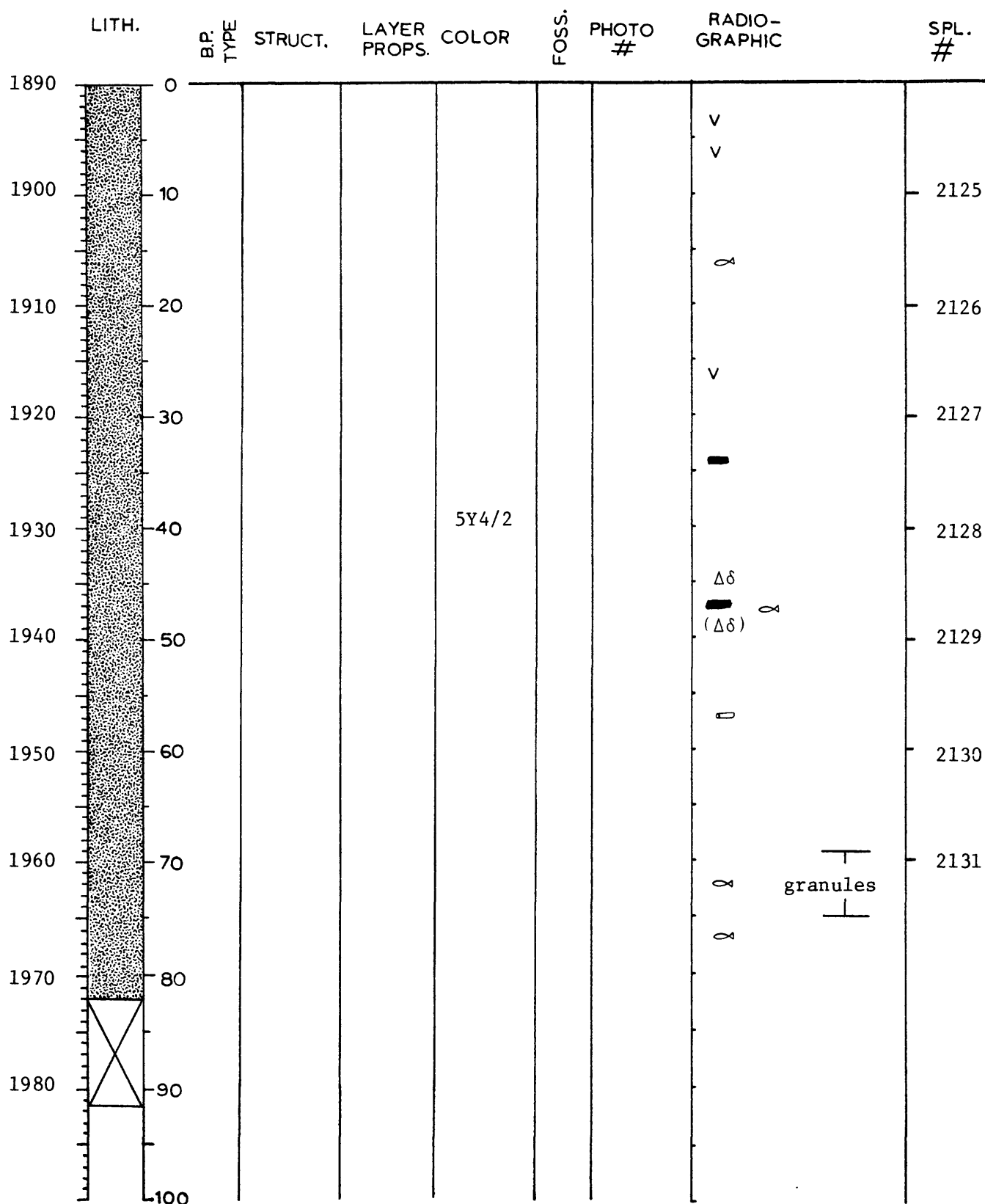
HOLE 5 SLUG 20 DEPTH 1798 cm. to 1890 cm.



bioturbation, disseminated vivianite, disseminated plant fragments, and disseminated fish bones throughout.

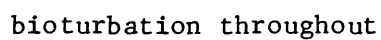
3" Ostenberg

HOLE 5 SLUG 21 DEPTH 1890 cm. to 1981 cm.

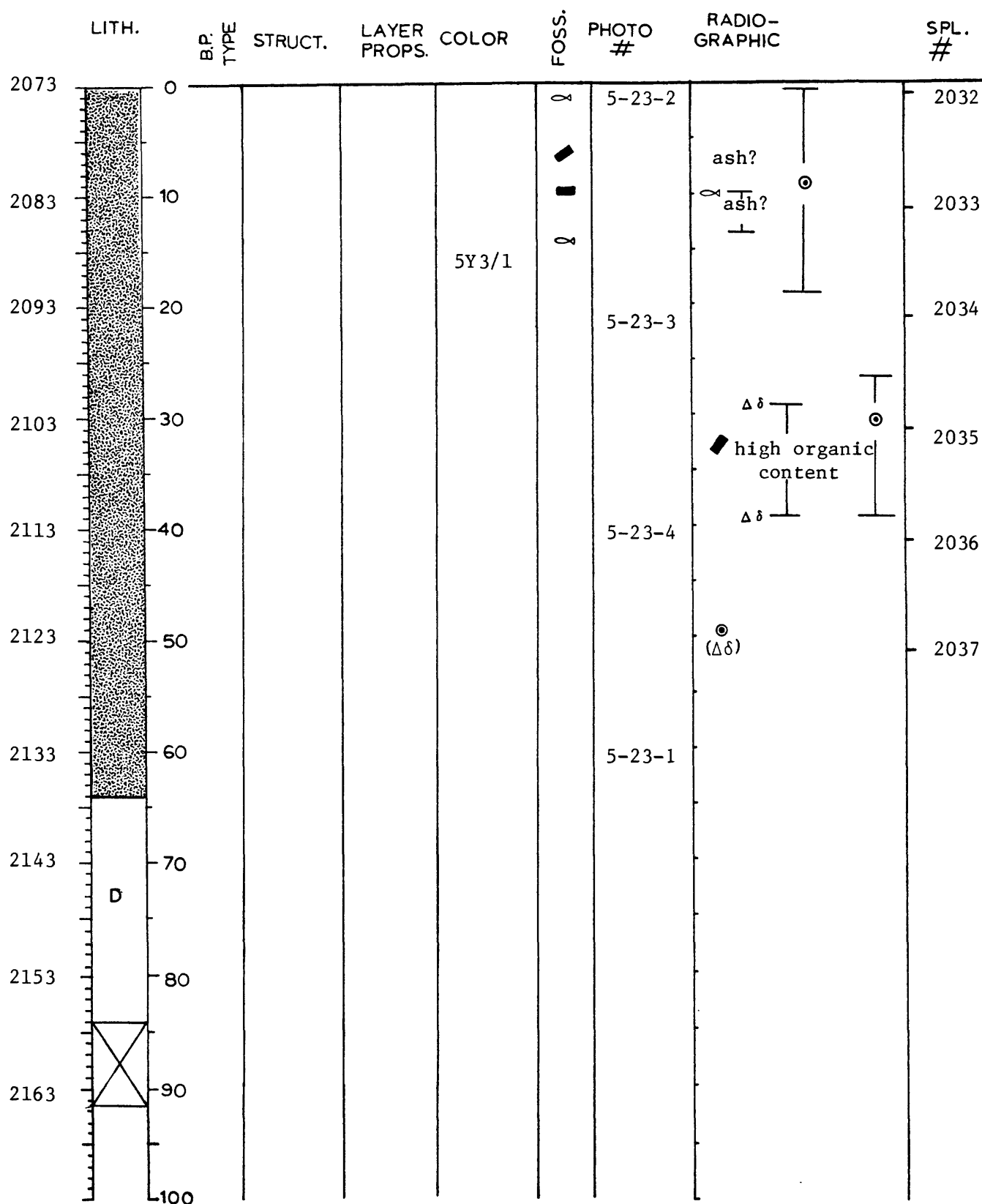


bioturbation throughout

HOLE 5 SLUG 22 DEPTH 1981 cm. to 2073 cm.

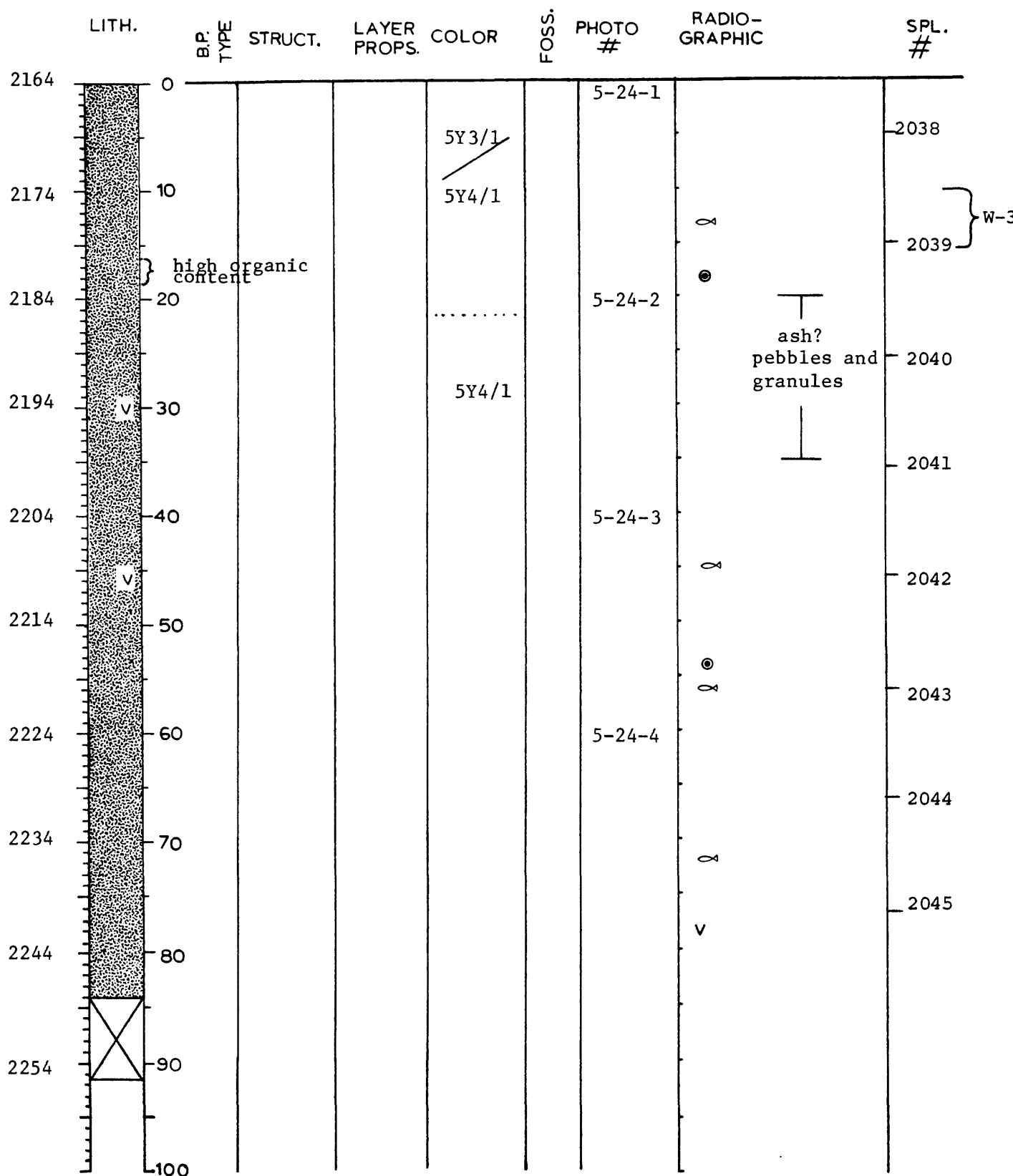


HOLE 5 SLUG 23 DEPTH 2073 cm. to 2164 cm.



disseminated granules and bioturbation throughout
oxidation along fractures

HOLE 5 SLUG 24 DEPTH 2164 cm. to 2256 cm.



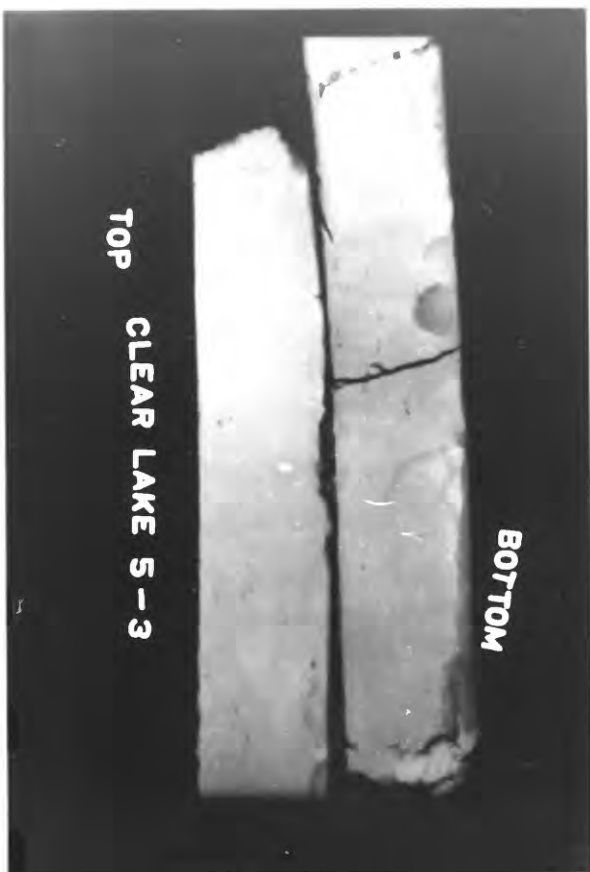
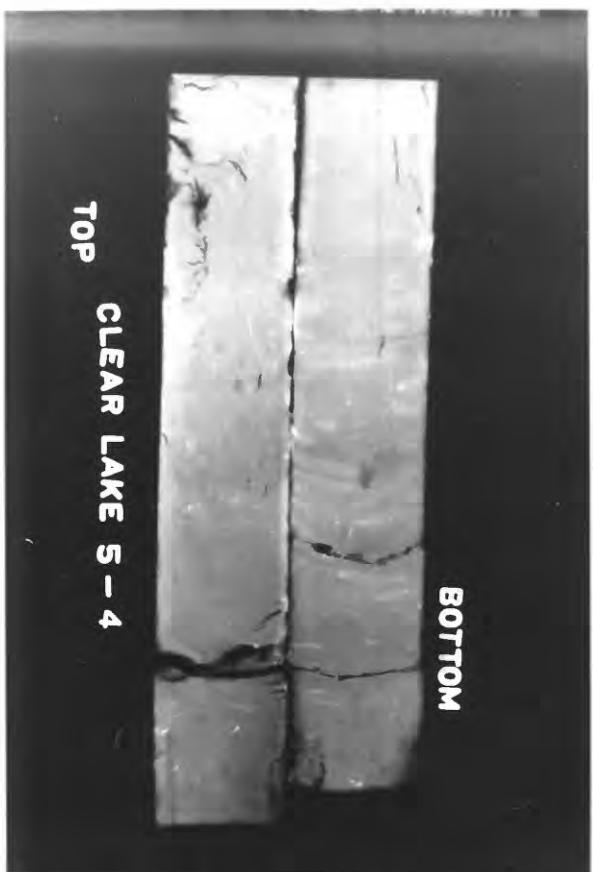
W-3220: 24,080 \pm 1,000 yr. BP

bioturbation and disseminated plant remains throughout.

Appendix B

.

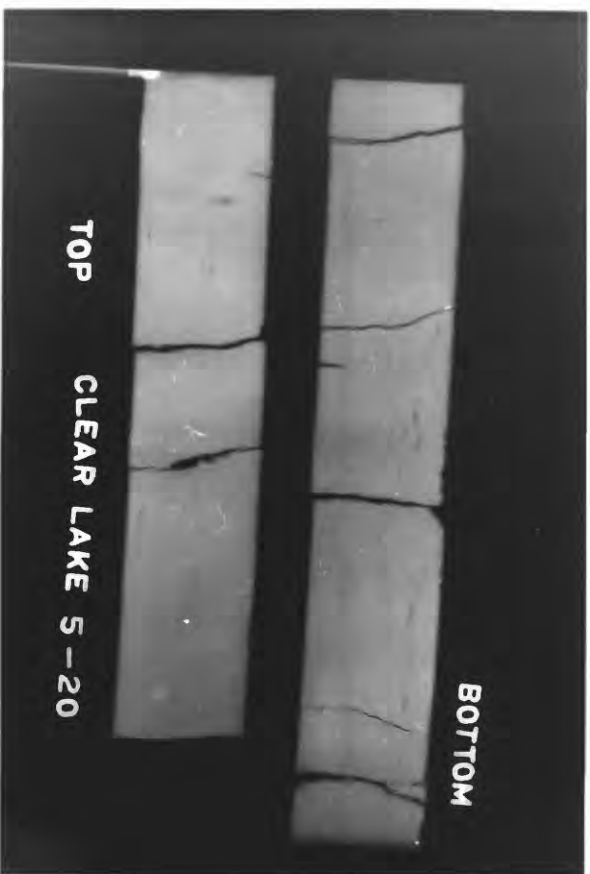
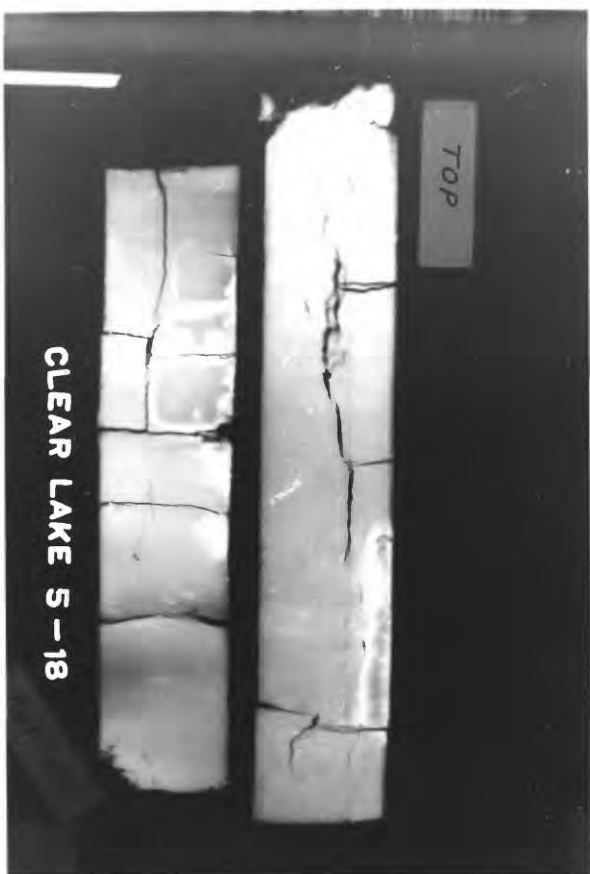
X-ray Radiographs













5-22
MISSING