8. SITE 91

The Shipboard Scientific Party[1]

SITE DATA

Occupied: March 12-15, 1970.

Position: 23°46.40'N; 93°20.77'W.

Water Depth: 3763 meters.

Total Depth: 900 meters.

Holes Drilled: One.

Cores Taken: Twenty-five.

BACKGROUND AND OBJECTIVES

The Sigsbee Basin of the Gulf of Mexico lies between the Sigsbee Scarp to the north (about 200 miles off the Texas-Louisiana coast) and the Campeche Scarp to the south (about 150 miles off the Yucatan Peninsula), and between the West Florida Escarpment to the east (about 120 miles west of the Florida coast) and the foot of the Mexican continental slope to the west (about 180 miles east of the Mexican coast). The Sigsbee Basin includes the Mississippi Cone to the east and the Sigsbee Abyssal Plain to the west and south. The Sigsbee Abyssal Plain is interrupted only by the Sigsbee Knolls, the first three of which were discovered by Ewing in 1954 (Ewing et al. 1958).

The study of thirty-three cores in 1953 led Ewing et al. (1955) from a consideration of the nature of the sediments cored, the topography of the Mississippi Cone, and the flat floor of the Sigsbee Deep, to the conclusion that the distribution of sediments in the Gulf of Mexico was profoundly influenced by turbidity currents. These authors also concluded, from seismic refraction measurements, that the crust was oceanic in character.

In 1954, a detailed topographic study, supplemented by 124 piston cores taken in the gulf (Ewing et al. 1958), led to the conclusion that silty sediments supplied in quantity by the Pleistocene Mississippi River and distributed by a turbidity current process covered the floor of the gulf.

Site 91 was located in the abyssal plain just beyond the foot of the continental rise to the Texas gulf coast. This site was chosen principally because the profiler records showed it to be in about the same geological position in the Sigsbee Abyssal Plain as Sites 3 and 87,but on the opposite side of the Sigsbee Knolls. Deep penetration at Sites 3 and 87 had been frustrated by slumping, and it was felt that this location might be more stable and that deeper penetration could be achieved.

Vema cruise 26 records had shown southerly dipping horizons, thinning to the south, which were overlapped by horizons from the south and east (Figures 1 and 2). Three other discontinuities evident in the profiler section could be penetrated by drilling to a depth of about 500 meters. It was thought that dating these three discontinuities could aid in interpreting the later sedimentary cycles within the gulf basin.

The *Glomar Challenger* profiler records of Leg 10 showed continuity of horizons from Site 90 to this side, and another objective was to confirm that these horizons were contemporaneous at the two sites. If so, great confidence could be placed in tracing these horizons throughout at least the western and southern basins, if not throughout the whole basin.

The *Glomar Challenger* cut 25 cores at Site 91 on March 12-15. The bottom core was recovered from a depth of 900 meters below the sea floor and consisted of Middle Miocene silty sand. A core inventory is given as Table 1.

NATURE OF SEDIMENTS

General Description

Site 91 was drilled near the center of the Sigsbee Abyssal Plain. The sediments, typified by the presence of olive gray, faintly laminated to massive clay or silty clay and texturally graded sands and silts, are categorized as turbidites and laminites. The sandy, coarse silts and very fine to fine sands are characteristically thin, although several examples of beds in excess of one meter thick are known. Sand probably comprises less than 10 per cent of the section.

A core of Upper Pliocene sediments is quite similar to overlying Pleistocene turbidites-laminites, although the fine-grained interbeds are characteristically more pelagic, containing thin beds of nannofossil-rich clay and clayey ooze. This can be compared with Site 87, where nannofossil ooze dominates the equivalent section.

The Miocene section penetrated at Site 91 is comparable in terms of facies with that drilled at Site 90, although the Upper Miocene interval appears considerably thinner at Site 91. Laminites and hemilaminites dominate to the base of the hole. The lowermost core (25) contains the coarsest debris in the entire sequence drilled, ranging up to gravelly, very coarse sand. This appears to correspond with the profiler record where persistent reflections are characteristic to considerably greater depth, as at Site 90. These basal sands are mineralogically immature and quite

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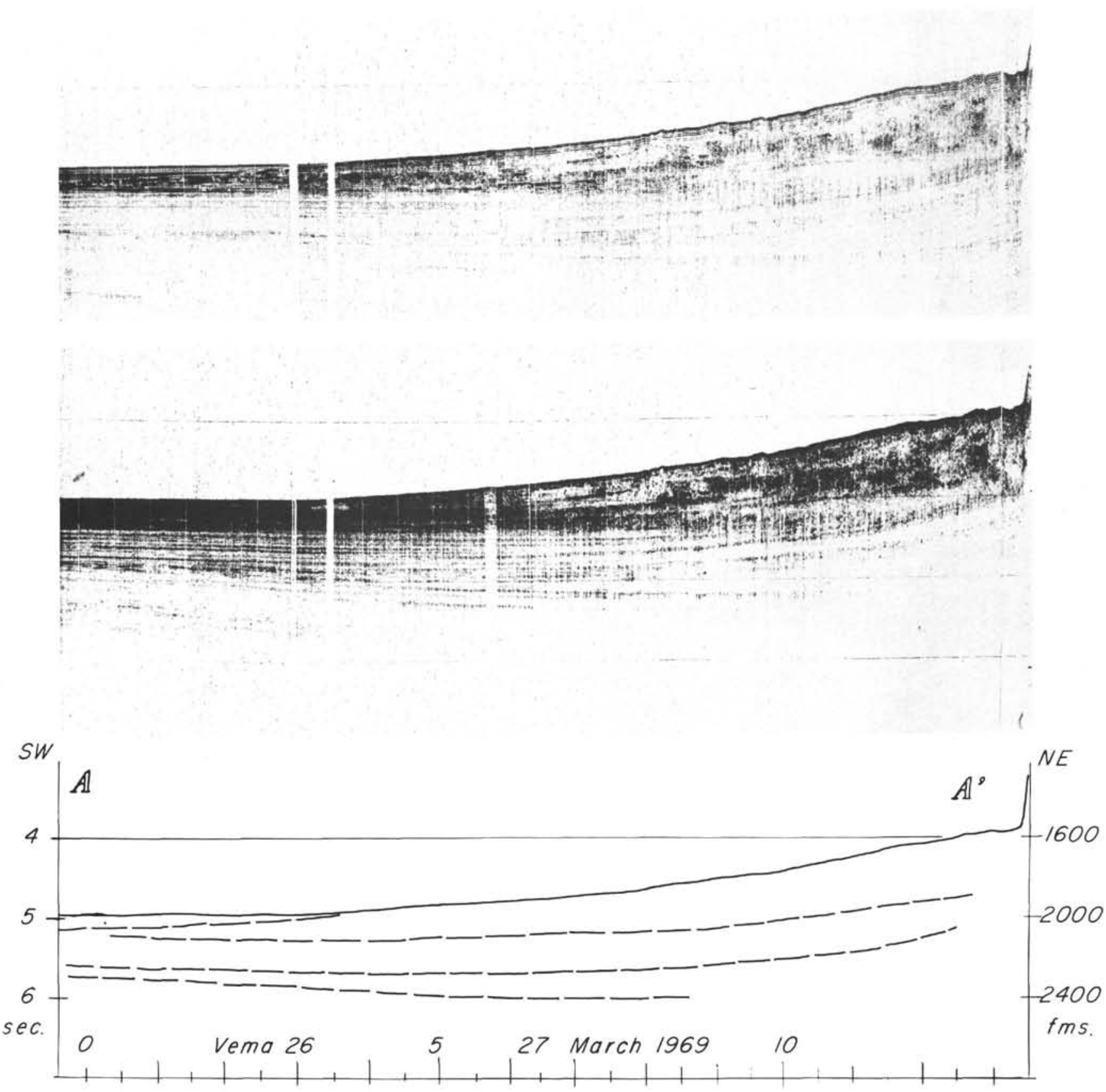

Figure 1. Vema *cruise 26 seismic records which show southerly dipping horizons thinning to the south.*

similar to those at the base of Site 90, suggesting a common source.

From a comparison of Sites 90 and 91, modified by inspection of the profiler record between those two sites, it can be demonstrated that the thick Pleistocene section of Site 91 probably received most of the terrigenous clastics from the Mississippi fan and other northern portions of the deep-water gulf. The presence of turbidites in Pliocene sediments at Site 91 and their general absence at Site 90 also suggests a northern or northeastern source.

Core 1 consists of olive gray, horizontally laminated, sometimes cross-laminated, texturally graded silt to sandy, coarse silt interbedded with massive to faintly laminated, rarely burrowed clay or silty clay. These sediments represent a mixed turbidite-laminite facies.

Core 2 is somewhat similar to Core 1 and consists of brownish gray, massive mud with zones of gray red clay, speckled with fecal microburrow fill intercalated with massive, olive gray, sandy mud with silt-filled microburrows throughout, and subsidiary olive gray, horizontal to cross-laminated, texturally graded, coarse silt to sandy silt. Variations in color of sediments in this core may indicate mixed sources of clastics (i.e., a north source

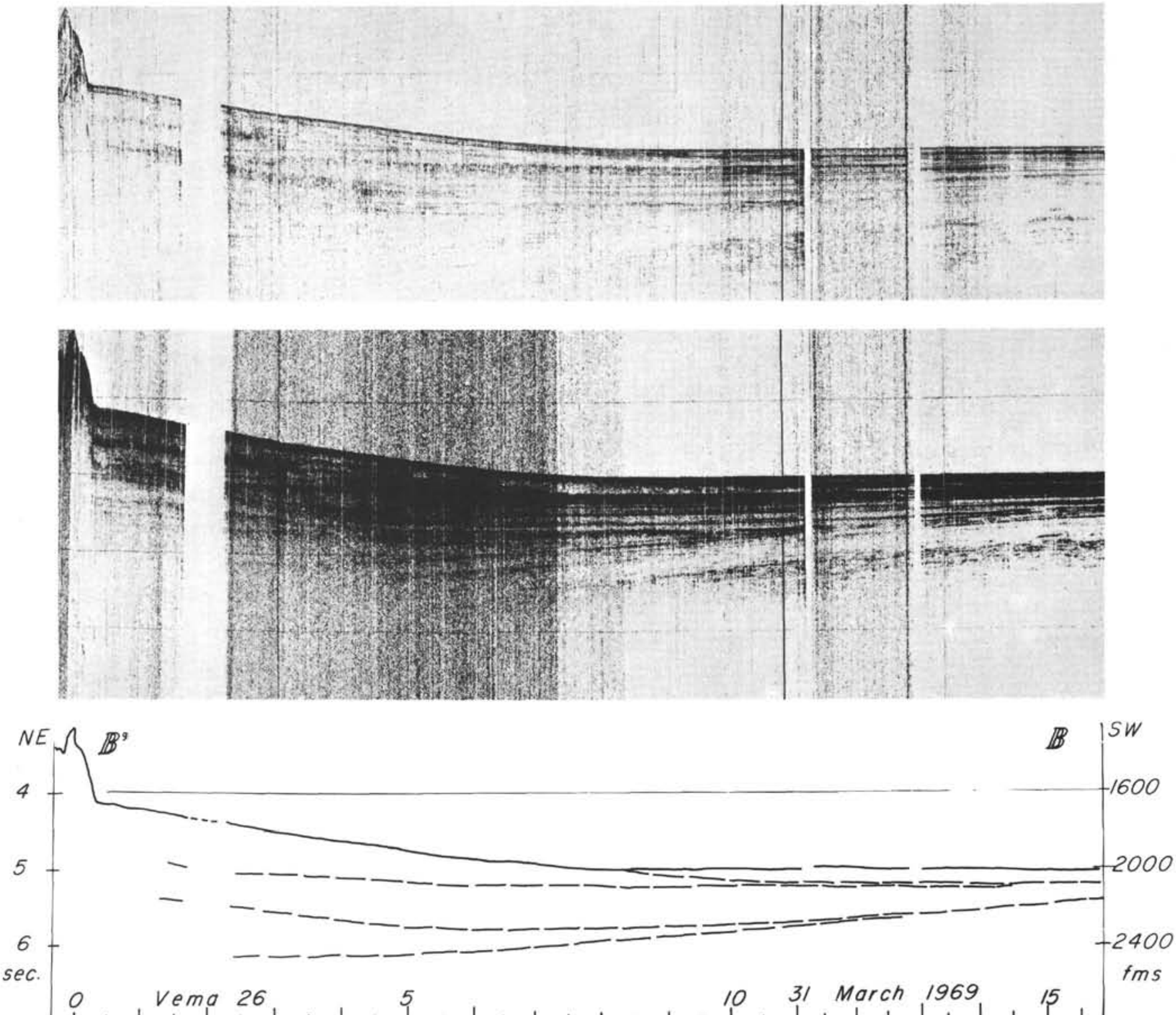

Figure 2. Vema *cruise 26 seismic profiles showing NE-SW relationships. Profile extends NE from Site 91.*

versus a Mississippi source). Facies designation is again laminite-turbidite.

Core 3 is quite similar to Core 1, containing lesser amounts of sand. Core 3 is described as olive gray, rarely burrowed to massive clay to mud, with silt-filled microburrows and common texturally graded, thin quartzose silt laminae and silty, coarse silt beds/bands. This core can be summarized as a laminite.

Cores 4 and 5 are again designated laminites, varying from olive green gray to brownish gray, massive to faintly laminated, rarely burrowed clay and silty clay with silt-filled microburrows and scattered fecal stain, interbedded with thin, texturally graded, sandy coarse silt laminae and horizontally to cross-laminated, sandy coarse silt to silt. Well laminated, unfossiliferous brownish gray clay occurs as the base of Core 5. Core 6 differs from the above only in a higher proportion of finely laminated, brownish gray to olive gray, unburrowed, unfossiliferous clay.

Core 7 contains several meters of disturbed (probably "cave" or mechanically disturbed) olive gray to gray, sandy, coarse silt to silty, very fine sand with some carbonaceous debris, overlying olive gray, relatively undisturbed, faintly laminated, rarely to moderately burrowed, sandy silt, silt, and clay, with silt/sand-filled microburrows and common thin, texturally graded, coarse silts and silty, very fine sands as in upper cores. This latter interval represents laminite sedimentation. The upper disturbed sand section indicates the presence of graded sand beds either immediately at the cored interval or at some distance above the coring interval (the latter is probably more likely).

Cores 8 and 9 also contain an upper zone of disturbed sand, as above, underlain by interbedded, olive gray to greenish gray to light olive gray, nannofossil-bearing clay/silt and clayey nannofossil ooze with intercalated thin quartzose silt/sand laminae/bands and gray, sandy,

TABLE 1
Core Inventory – Site 91

Core	No. Sections	Date	Time	Cored[a] Interval (m)	Cored (m)	Recovered (m)	Subbottom Penetration (m) Top	Bottom	Lithology	Age
1	6	3/12	0600	3823-3832	9.0	8.4	60.0	69.0	Sand & silty clay	Late Pleistocene
2	5	3/12	0800	3886-3895	9.0	6.3	123.0	132.0	Silty clay	Late Pleistocene
3	6	3/12	1000	3922-3931	9.0	9.0	159.0	168.0	Silty clay & sand	Late Pleistocene
4	6	3/12	1200	3940-3949	9.0	9.0	177.0	186.0	Silty clay	Late Pleistocene
5	6	3/12	1430	3949-3958	9.0	9.0	186.0	195.0	Silty clay	Late Pleistocene
6	6	3/12	1830	4064-4073	9.0	7.5	301.0	310.0	Silty clay	Middle Pleistocene
7	5	3/12	2230	4170-4176	6.0	7.0	407.0	413.0	Silty sand & clay	Middle Pleistocene
8	2	3/13	0200	4253-4258	5.0	3.0	490.0	495.0	Silty sand	Early Pleistocene
9	6	3/13	0500	4293-4301	8.0	8.3	530.0	538.0	Silty sand & nanno ooze	Late Pliocene
10	4	3/13	1030	4415-4421	6.0	6.4	652.0	658.0	Silty sand	Middle Miocene
11	4	3/13	1630	4533-4542.2	9.2	5.7	770.0	779.2	Sand & silty clay	Middle Miocene
12	3	3/13	1830	4542.2-4551.4	9.2	3.5	779.2	788.4	Sand & silty clay	Middle Miocene
13	3	3/13	2030	4551.4-4560.6	9.2	4.2	788.4	797.6	Silty clay	Middle Miocene
14	2	3/13	2215	4560.6-4569.8	9.2	3.5	797.6	806.8	Silty sand & clay	Middle Miocene
15	3	3/14	0000	4569.8-4579.0	9.2	4.7	806.8	816.0	Silty clay	Middle Miocene
16	3	3/14	0145	4579.0-4588.2	9.2	4.0	816.0	825.2	Silty clay	Middle Miocene
17	6	3/14	0325	4588.2-4597.4	9.2	9.2	825.2	834.4	–	–
18	6	3/14	0500	4597.4-4606.6	9.2	9.2	834.4	843.6	Silty clay & sand	Middle Miocene
19	3	3/14	0630	4606.6-4615.8	9.2	3.8	843.6	852.8	–	–
20	6	3/14	0830	4615.8-4625.0	9.2	9.2	852.8	862.0	Silty sand	Middle Miocene
21	6	3/14	1015	4625-4629	4.0	9.2	862.0	866.0	–	–
22	2	3/14	1530	4629-4635	6.0	2.8	866.0	872.0	Mudstone	Middle Miocene
23	–	3/14	1715	4635.0-4644.2	9.2	0.1	872.0	881.2	–	–
24	–	3/14	1930	4644.2-4653.4	9.2	0.0	881.2	890.4	–	–
25	4	3/15	0100	4653.4-4662.6	9.2	5.7	890.4	899.6	Silty sand	Middle Miocene
Total	113				208.6	148.7		900.0		
% Cut					23.2%					
% Recovered						71.3%				

[a]Drill pipe measurement from derrick floor.

coarse silt to silty, very fine sand, texturally graded. Thus Cores 8 and 9 represent intercalated turbidites and hemilaminites. Core 10 represents an increase in silt laminae/bands, whereas the fine-grained interbeds remain nannofossil-bearing. Core 10, thus, qualifies as a laminite interval.

Cores 11 through 25, continuously cored, represent a general increase in sand percentage downwards, culminating in a relatively high sand percentage at the base of the hole. Sediments throughout the continuously cored interval range from vaguely to moderately laminated, moderately burrowed, color laminated as greenish gray to olive gray to brownish gray, unfossiliferous to slightly nannofossil-bearing mud and clay (hemilaminite), with occasional thin, graded silt laminae (laminite). Well laminated, olive brown mudstone with thin graded beds of very poorly sorted, clayey to silty, very fine sand, horizontally bedded and carbonaceous debris-rich, appear to become more common in the lower part of the interval (Core 16).

The presence of considerable amounts of disturbed ("cave"?) gray sand in the lower cores indicates an increasing sand percentage toward the bottom of the hole. Grain size also increases. This is interpreted to indicate the presence of thicker and coarser grained turbidites with depth. Core 25, perhaps, represents the thickest and coarsest sand units yet recovered from the deep-water Gulf of Mexico. Although most of the core appears disturbed, the basal section consists of texturally graded, very fine to gravelly, very coarse sand, poorly sorted with mudclasts up to 15 mm in size. Rock fragments and quartz grains up to 5 mm also occur. Carbonaceous debris is common. These sands are mineralogically immature and quite similar to those reported at the base of Site 90, although apparently coarser grained.

Petrographic study of the very coarse sand revealed an assemblage of plagioclase feldspar, quartz, biotite, green and brown hornblende, and carbonate rock fragments. Volcanic rock fragments, chert, chlorite grains, zircon, rutile, and tourmaline comprise the remainder of the assemblage. Only traces of potassium feldspar appear to be present. Volcanic rock fragments are common, ranging from Fe-rich glass to fine-grained, feldspathic microlitic fragments. Sedimentary rock fragments consist of (a) carbonate rock fragments, including "Cretaceous-appearing" limestone and dolomite, and (b) dark, cemented sandstone fragments. Contemporaneously derived clam and gastropod shell debris (of Miocene age?) as well as coral fragments complete the sedimentary rock fragment assemblage. Abraded chlorite grains suggest a subsidiary low-grade metamorphic terrain. As discussed previously, this assemblage appears to support a Rio Grande embayment source as the most likely clastic provenance.

The Pleistocene sands and coarse silts, by way of contrast, are considerably less plagioclase-rich, have a higher proportion of potassium feldspar to plagioclase feldspar, a higher relative percentage of dolomite rhombs (considered detrital), and a less complex heavy mineral suite. Although it might be argued that the finer grained nature of the Pleistocene sands is responsible for the more mature mineralogical assemblage, as compared to the Miocene sands, it seems apparent that various lines of evidence point to basically different sources for the two intervals. These points are presented in the following section.

Sedimentological Interpretation

The thick sequence of Pleistocene turbidites and laminites present at Site 91 presents an opportunity to characterize the abyssal plain in terms of sediment source. Although data are somewhat meager, it is thought that sediment color may be a primary indication of distinctive source Terrains, the olive gray clayey silts and associated sands representative of a Mississippi Fan/north central Gulf source. The reddish brown to brownish gray clays/silts and dark gray to gray sands appear to represent the northern Gulf (Louisiana-East Texas) and northwestern Gulf (Rio Grande embayment) region, based on presently available data.

Several discontinuities within the Plio-Pleistocene section at Site 91 (Worzel, this volume) appear to offer support for interpretation of multiple sources and were initially suggestive of such a relationship. The material above approximately 180 meters appears to have been largely derived via the Mississippi Fan, although subsidiary amounts of northern/northwestern Gulf reddish muds are present. Sediment below 180 meters to approximately 300 meters may reflect a more important northern/northwestern source, although core coverage is less than optimum for such an interpretation. Based on the profiler record, the interval from 320 meters to 400 meters may be predominantly clay/silt of indeterminate source. No cores were obtained from this interval.

The larger proportion of remaining Upper Pleistocene sediment, from 400 to approximately 460 meters, is evidently of Mississippi Fan derivation, as based on analysis of Core 7. Below this level, most of the graded sands appear to represent a northwestern Gulf source, being characterized by dark gray to gray sands with an immature mineralogical and rock fragment assemblage. This continues to the bottom of the hole (Middle Miocene).

The thick sequence of Miocene laminite and hemilaminite occurring at Site 90, which thins eastward to Site 91, suggests a general proximal-distal facies configuration as one moves basinward. The general absence of graded sand turbidites in Pliocene and Lower Pleistocene sediments at Site 90 and the presence of thick, coarse-grained, northwestern Gulf Miocene turbidites at Site 91 suggest that Site 90 lies somewhat south of the main axis of sediment transport operative during Miocene time.

The gradual shift in prime sediment source upwards through the section penetrated at Site 91 suggests either shifting depocenters on the northern Gulf clastic-dominated shelf or that the abyssal plain has had a varied bathymetric configuration during upper Cenozoic sedimentation. Both factors may operate concurrently. The profiler records seem to indicate that at times during Pleistocene sedimentation a bathymetric low may have existed to the north (and to the east?) of the present Sigsbee Deep. Progradation and aggradation of the northern continental rise as well as the Mississippi Fan appears to have fluctuated considerably during the Pleistocene, possibly a reflection of shifting depocenters. The area beneath the

Mississippi Fan may thus have been a rather isolated bathymetric deep at some earlier time, either in Pliocene or Early Pleistocene time. This would have largely prevented delivery of Mississippi-type sediments to the site of Site 91, or at least have diverted a large percentage of the coarser clastics.

The sequence of Miocene turbidites, evidently quite thick as judged from the profiler record, indicates a prolonged period of turbidite sedimentation. As discussed for Site 90, this appears to argue for eustatic changes of sea level during Middle Miocene time.

Physical Measurements

Penetrometer measurements indicate normal to slightly less than normal consolidation with depth. Comparing Site 91 with Site 90 shows that the Pleistocene section of Site 91 is slightly less consolidated than that of Site 90, suggesting that the higher rate of accumulation of Pleistocene sediment at Site 91 is responsible for the slower rate of consolidation. On the other hand, bulk density measurements are comparable between the two sites (within the limits of error), suggesting that the relationship is complex. The average bulk density of Core 1 is high, evidently a reflection of the high percentage of sand.

Disturbance of core through the remainder of the hole tends to cast considerable doubt on GRAPE measurements and bulk density comparisons, especially below approximately 450 meters. Undercutting of the more consolidated or semi-consolidated sediments below this depth suggests that bulk densities are only grossly indicative of increasing density with depth.

Natural gamma measurements at Site 91 appear to correlate reasonably well with terrigenous clay content. Cores 8, 9, and 10 are especially notable in that the higher percentage of pelagic components (carbonate) is probably responsible for the low gamma count. The immature sandstones at the base of the hole are again surprisingly high, as at Site 90, suggesting that the immature mineralogy of the sandstones is responsible. Cores 11 and 13 contain thin zeolite-enriched zones, which give a locally high gamma count similar to that observed at Site 90.

The presence of methane-rich natural gas was again detected, persisting to a greater depth than at previous sites. This persistence to greater depth may reflect the high rate of Pleistocene sedimentation and a resultant lower level of consolidation.

BIOSTRATIGRAPHY

The biostratigraphy of Site 91 is summarized in Figure 3. The interpretation is based on examinations of the foraminifera and calcareous nannofossils. The samples also were examined for radiolarians, but no significant occurrences were noted.

The biostratigraphies of the sections penetrated are very similar for Sites 90 and 91, although the times of maximum sedimentation differ greatly at the two sites. Thickness of the total sediments deposited since approximately the end of Early Miocene is greater by 200 meters at Site 91. The difference in the thicknesses of the Quaternary sections at the two sites is greater than the difference in overall thicknesses ($\pm$ 350 meters thicker at Hole 91). The Middle and Late Miocene sediments are actually thinner at Site 90 than at Site 91. Approximate thickness relationships are illustrated in Figure 4. One interpretation of the relationships is that the major source of clastic sediments shifted from west to east during deposition of the section (probably from Rio Grande dominance to Mississippi dominance). This interpretation is strengthened by an upward change in mineral suites in both the highly diluted, predominantly clastic sections.

Sample 1(10-91-1, CC):
Globorotalia truncatulinoides, Globigerina inflata, Globigerinoides ruber (pink), *Coccolithus pelagicus,* s.s., and *Cyclococcolithus leptoporus leptoporus.*
Age: Late Pleistocene, probably late Wisconsinan (glacial); *Globorotalia truncatulinoides* Zone; *Pulleniatina finalis* Subzone.
Environment: Bathyal.
Remarks: A few reworked Cretaceous nannofossils were noted, including species of *Arkhangelskiella, Watznaueria,* and *Micula.*

Sample 2 (10-91-2, between segments 2 and 3):
Globorotalia truncatulinoides, G. menardii (rare), *Globigerina inflata, Globigerinoides ruber* (pink), *Gephyrocapsa oceanica, G. kamptneri, Coccolithus pelagicus* s.s., *Oolithotus antillarum,* and *Pseudoemiliania* sp.
Age: Late Pleistocene, probable early Wisconsinan (glacial): *Globorotalia truncatulinoides* Zone; *Pulleniatina finalis* Subzone.
Environment: Bathyal.

Sample 3 (10-91-3, CC):
Globorotalia truncatulinoides, Globigerina inflata, Globigerinoides ruber (pink), *Coccolithus pelagicus* s.s., *Pseudoemilania* sp. cf. *P. lacunosa, Reticulofenestra* sp., and *Coccolithus pelagicus,* s.1.
Age: Late Pleistocene, probable late Illinoian (glacial): *Globorotalia truncatulinoides* Zone; *Pulleniatina finalis* Zubzone.
Environment: Bathyal.

Sample 4 (10-91-4, CC):
Globigerina inflata, Globigerinoides ruber (pink), *Hastigerina aequilateralis, Coccolithus pelagicus* s.s., *Helicopontosphaera sellii, Pseudoemiliania* sp., *Rhabdosphaera stylifer,* and *Ceratolithus cristatus.*
Age: Late Pleistocene, probable late Illinoian (glacial): *Globorotalia truncatulinoides* Zone; *Pulleniatina finalis* Subzone.
Environment: Bathyal.
Remarks: Reworked calcareous nannofossils include the Miocene-Pliocene forms, *Cyclococcolithus neogammation* and *Reticulofenestra pseudoumbilica.*

Sample 5 (10-91-5, CC):
Globorotalia truncatulinoides, G. tumida, Globigerinoides ruber (pink), *Globigerina inflata, Coccolithus pelagicus* s.s., *Cyclococcolithus leptoporus leptoporus,*

SITE 91 **WATER DEPTH 3763 METERS**

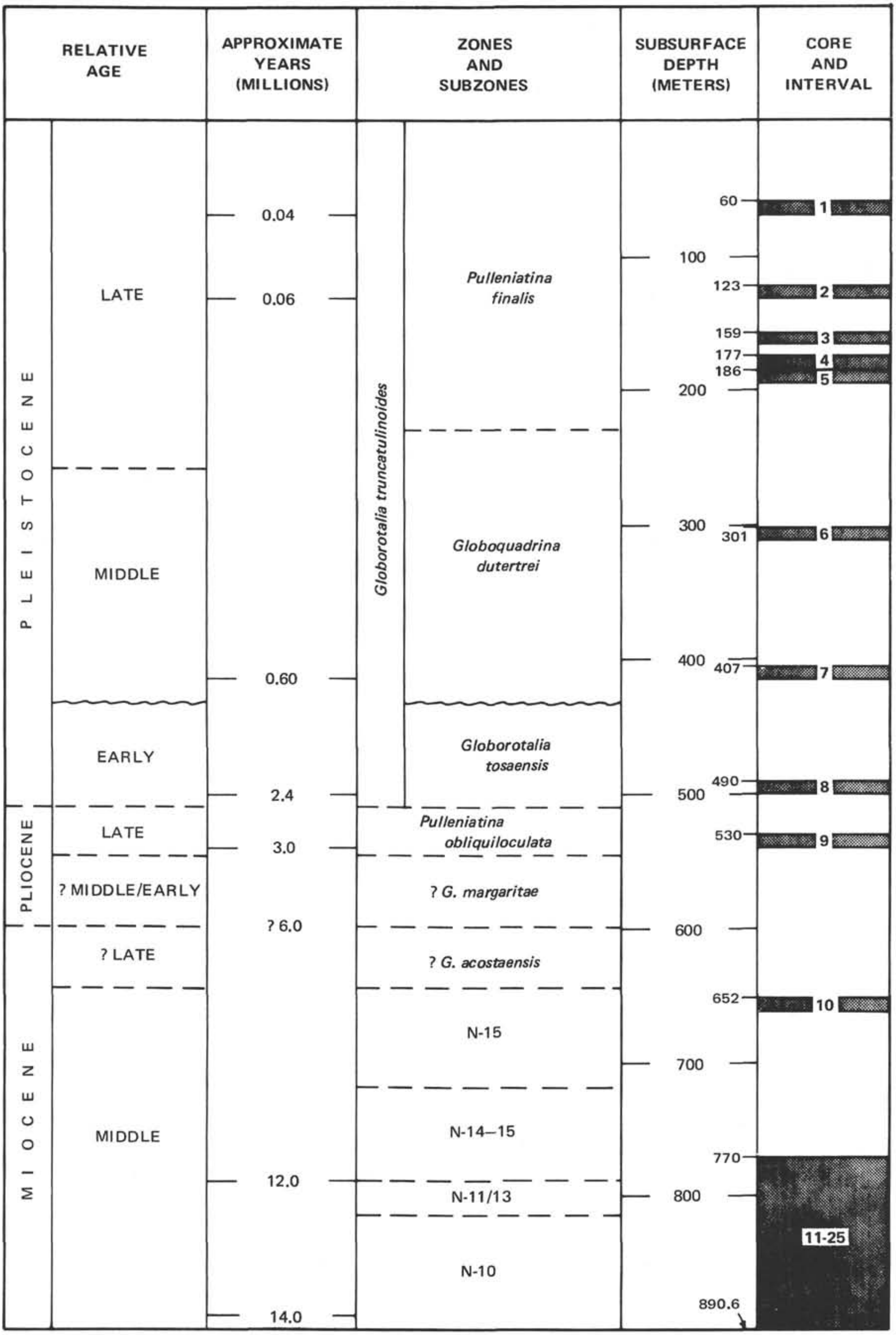

Figure 3. *Biostratigraphic summary of Site 91.*

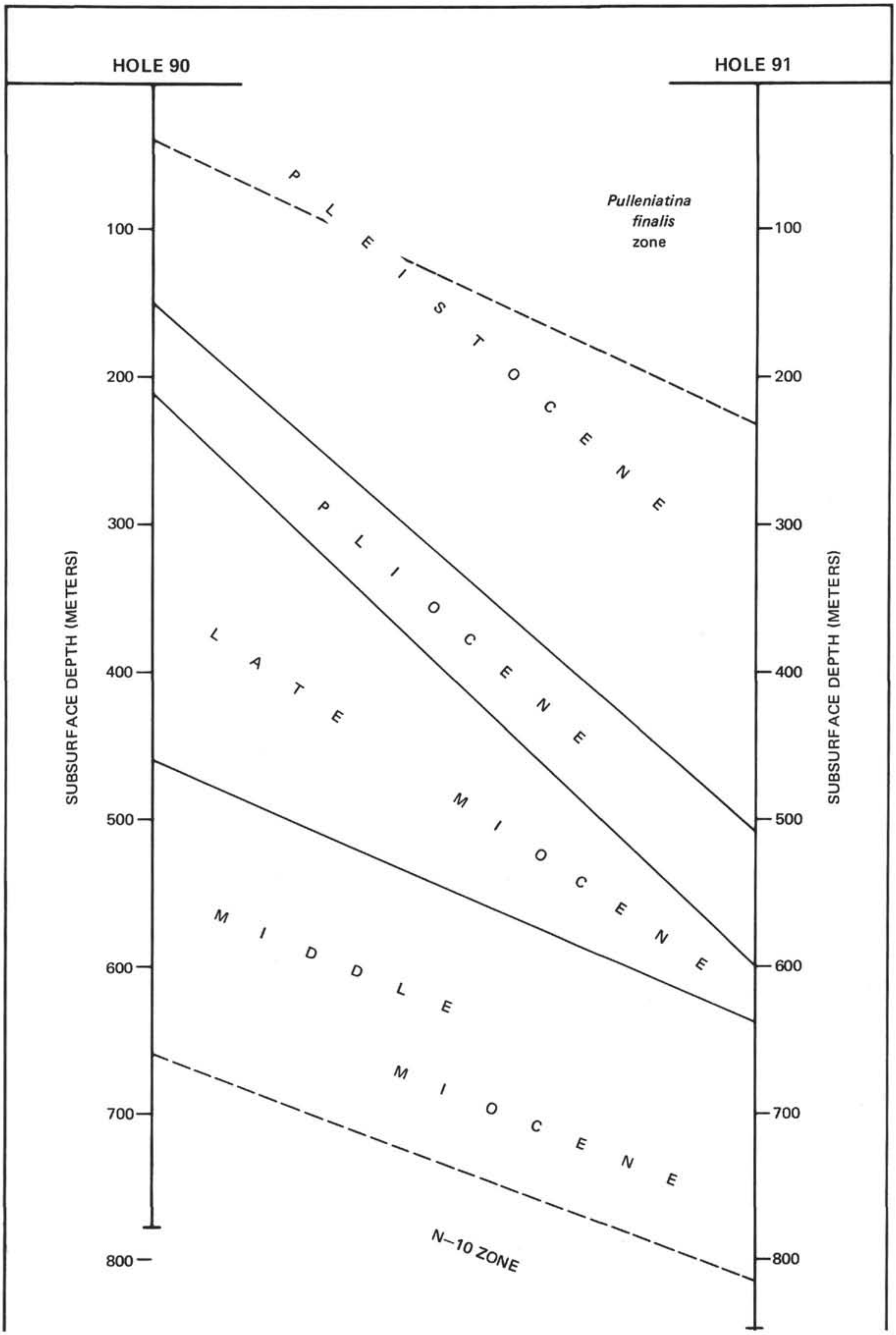

Figure 4. *Approximate thickness relationships of sediments in Holes 90 and 91.*

Pseudoemiliania sp., *Reticulofenestra* sp., and *Discolithina millipuncta*.
Age: Late ? Pleistocene, Illinoian (glacial): *Globorotalia truncatulinoides* Zone; ?*Pulleniatina finalis* Subzone.
Environment: Bathyal.
Remarks: Reworked Miocene calcareous nannofossils include *Catinaster coalitus, Discoaster exilis, D. challengeri, D. bollii, D. quinqueramus,* and *Cyclococcolithus neogammation.*

Sample 6 (10-91-6, CC):
Globorotalia truncatulinoides, G. scitula, Globigerina inflata, Globigerinoides ruber (pink), *G. triloba, Coccolithus pelagicus* s.s., and *Pseudoemiliania* sp.
Age: Middle Pleistocene, probable early Illinoian (glacial): *Globorotalia truncatulinoides* Zone; ?*Globoquadrina dutertrei* Subzone.
Environment: Bathyal.
Remarks: Reworked Cretaceous calcareous nannofossils are common.

Sample 7 (10-91-7, CC):
Globorotalia truncatulinoides, G. scitula, Globigerina inflata, Globigerinoides ruber, G. quadrilobata, G. sacculifera, Coccolithus pataecus, Helicopontosphaera sellii, Pseudoemiliania lacunosa, Discolithina anisotrema, and *Gephyrocapsa* sp. cf. *G. caribbeanica.*
Age: Middle Pleistocene, early Illinoian; *Globorotalia truncatulinoides* Zone; ?*Globoquadrina dutertrei* Subzone.
Environment: Bathyal.

Sample 8 (10-91-8, CC):
Globorotalia truncatulinoides, G. miocenica, Sphaeroidinella dehiscens, (abundant), *Globigerina inflata, Globigerinoides ruber* (white), *Discoaster brouweri, Reticulofenestra pseudoumbilica, Pseudoemiliania lacunosa, Scyphosphaera pulsherrima,* and *Cyclococcolithus leptoporus macintyrei.*
Age: Early Pleistocene, Nebraskan: *Globorotalia truncatulinoides* Zone; *Globorotalia tosaensis* Subzone.
Environment: Bathyal.

Sample 9(10-91-9, CC):
Globoquadrina altispira, G. venezuelana, Globorotalia multicamerata, G. miocenica, Globigerinoides obliqua, Discoaster brouweri, D. surculus, D. pentaradiatus, D. asymmetricus, Reticulofenestra pseudoumbilica, and *Ceratolithus rugosus.*
Age: Late Pliocene: *Pulleniatina obliquiloculata* Zone.
Environment: Bathyal.

Sample 10 (10-91-10, CC):
Globigerina nepenthes, Globorotalia sp. cf. *G. acostaensis, Discoaster brouweri, D. surculus, D. variabilis, D. exilis, D. quinqueramus, Reticulofenestra pseudoumbilica,* and cf. *Catinaster* sp.
Age: Late Middle Miocene (N. 15): *Globorotalia menardii* Zone.
Environment: Bathyal.

Sample 11 (10-91-11, CC):
Globigerina sp. cf. *G. nepenthes, Globorotalia* sp. cf. *G. menardii* var., *Cyclococcolithus leptoporus macintyrei, Pseudoemiliania* sp., and *Coccolithus minutulus.*
Age: Middle Miocene (?N. 14/15).(
Environment: Probable bathyal.
Remarks: Both fauna and flora rare; age based partly on superposition.

Sample 12 (10-91-12, CC):
Age: ?Middle Miocene.
Remarks: No planktonics (fauna or flora) were recovered from this sample. Sample appears to be highly diluted with terrigenous clastics.

Sample 13 (10-91-13, CC):
Globorotalia fohsi robusta.
Age: Middle Miocene (N. 12/early N. 13)
Environment: Bathyal.
Remarks: No calcareous nannofossils were noted. Benthonic foraminifera include species of *Gyroidina, Ellipsonodosaria,* and *Laticarinina.*

Sample 14 (10-91-14, CC):
Globorotalia fohsi fohsi, G. mayeri, Globoquadrina altispira, Discoaster brouweri, D. exilis, D. sp. aff. *D. bollii, Helicopontosphaera sellii,* and *Reticulofenestra pseudoumbilica.*
Age: Middle Miocene (N. 10/11)
Environment: Bathyal.

Sample 15 (10-91-15, CC):
Sample 16 (10-91-16, CC):
Sample 17 (10-91-17, CC):
Sample 18 (10-91-18, CC):
Sample 19 (10-91-19, CC):
Sample 20 (10-91-20, CC):
Sample 21 (10-91-21, CC):
Sample 22 (10-91-22, CC):
Sample 23 (10-91-23, CC):
Sample 24 (10-91-24, CC):
Sample 25 (10-91-25, CC):
Ages: Early Middle Miocene (N. 10, no older than N. 9)
Environment: Bathyal.
Remarks: Sample 25 still contains *Orbulina universa,* and *Globorotalia fohsi fohsi* was recovered from most samples. *Discoaster* sp. cf. *D. exilis* also was found in most samples.

DISCUSSION AND INTERPRETATION

Twenty-five cores, ranging from Middle Miocene to Holocene in age, were cored in an 899.6-meter interval. The Pleistocene section was approximately 510-meters thick and represents the thickest complete Pleistocene sequence drilled in the deep sea up to this time (Figure 5).

The Pliocene is 120-meters thick, the upper Miocene, 130 meters, and the Middle Miocene at least 100-meters thick. The sediments recovered are mostly turbidities consisting of olive gray, faintly laminated to massive silts and clays and texturally graded sands and silts. The Pleistocene and Pliocene sediments are quite similar except for

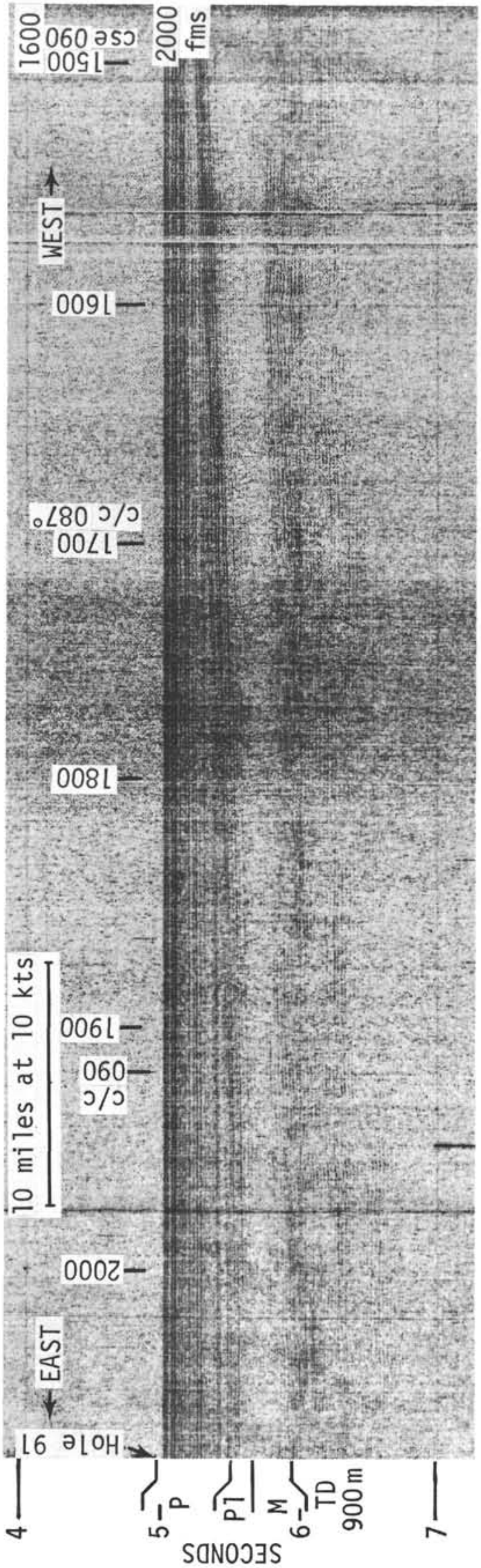

Figure 5. *On-site seismic profile showing thicknesses of Pleistocene and Pliocene sediments.*

an increase in the percentage of pelagics in the Pliocene material.

The Miocene section consists of laminites and hemilaminites. The lowermost section contains the coarsest debris in the entire drilled sequence (Figure 6, Core 25). The size of the material ranges from fine sand to pebbly, very coarse sand and consists of mineralogically immature sand quite similar to that found at the base of Site 90, suggesting a common source.

A considerable amount of gray sand was encountered at the lower depths. The occurrence of thicker and coarser grained turbidites with depth in Site 91 is indicated by increasing sand percentage and grain size. Examination of the very coarse sand turbidite(s) reveals a dominantly plutonic assemblage of quartz, K-feldspar, hornblende, biotite, and tourmaline. In addition, Cretaceous limestone and dolomite, dark cemented sandstone fragments, shell debris, and coral fragments are found in the material.

The sediments in the first five cores, late Illinoian in age, are entirely terrigenous quartzose or clay mineral-rich silts and clays. Detrital carbonate is a common to abundant constituent.

A marked increase in calcareous nannofossils occurs in the cores of the sections of Illinoian through Early Pleistocene ages. Otherwise, the sediments representing this sequence are similar to the late Illinoian section. In the Pliocene sediment recovered, calcareous nannofossils are common to dominant and, in two sections, sufficiently rich in number to classify the sediment as nanno ooze. Terrigenous clastics containing rock fragments, feldspar, amphibole, and zircon-rich heavy mineral assemblages occur in the abundant to dominant range and zeolites make their first appearance and are classed as rare to abundant.

Sixteen cores recovered from depths between 652 to 900 meters were determined to be Miocene in age. Examination of this material indicates the following: (a) Terrigenous detritus are the most abundant constituents; (b) quartz, rock fragments, detrital carbonate, and clay minerals are the primary detrital constituents; (c) the sediments are compositionally and texturally immature; (d) zeolites occur in a small number of sections; (e) volcanic glass is present in minor amounts; and (f) heavy mineral-bearing (amphibole and zircon-rich) lithic sands are common constituents in the cores.

Rates of deposition for various times since the Middle Miocene for the area in the vicinity of Site 91 are as follows:

Pleistocene	
Present to 40,000 B.P.	150 cm/10^3y
40,000 B.P. to 60,000 B.P.	320 cm/10^3y
60,000 B.P. to 600,000 B.P.	55 cm/10^3y
Average rate for:	
Late Pleistocene	50 cm/10^3y
Early Pleistocene	10 cm/10^3y
Entire Pleistocene	20 cm/10^3y
Pliocene	4 cm/10^3y
Miocene	3.7 cm/10^3y

The average rate of deposition from the Holocene to the Middle Miocene (14 my period) is 6.4 cm/10^3y.

It is interesting to compare the rates of deposition as determined for Site 90 with those for Site 91. Late Pleistocene deposition in Site 91 is four times that of Site 90, Early Pleistocene is three times that of Site 90, and Pliocene deposition is similar for both holes. The rates for the Miocene of Site 90 are about the same as those for Site 91.

The *average* rate of deposition for the sections cored from Sites 90 and 91 are identical. Thus, the sedimentation during Miocene times at Site 90 was comparable to the effects of Pleistocene sedimentation in the central portions of the basin. This comparison is extremely hard to explain when one considers the relatively isolated position with respect to known sediment transportation routes of the area in the vicinity of Site 90.

Examination of the seismic profile from Site 90 to Site 91 shows that the Pleistocene thickens to the east (Figure 4, chapter 7) and the Miocene thins to the east. North-south seismic profiles through Site 91 to the Sigsbee Scarp (Figures 1 and 2) show that the Pleistocene thickens to the north, while the Miocene remains almost constant but dips to the north. The seismic profiles show that at Site 91 the major source of sediments during the Pleistocene was from the north and east, mainly the Texas-Louisiana shelf and slope and the Mississippi River. It is difficult to believe that appreciable amounts of material could be transported from the north across the complex structure of the Texas-Louisiana continental slope, but the evidence does indicate it. Four discontinuities in the N-S sections occur within the Pleistocene. These discontinuities are believed to indicate a shifting source of sediments to the north and east during various stages of the Pleistocene. The majority of Miocene sediments are interpreted as having their source to the west, mainly the Rio Grande embayment.

The sequence of Miocene turbidites at Site 90 indicates a prolonged period of turbidite sedimentation. It is suggested that a eustatic change of sea level during the Middle Miocene is the best explanation for the observations derived from studies of Sites 90 and 91.

The physical measurements of the cored sections indicate that: (a) the sediments are normally consolidated to underconsolidated, a result of the high rates of deposition at Site 90; (2) bulk density measurements are comparable between Sites 90 and 91; and (c) natural gamma measurements appear to correlate reasonably well with the terrigenous clay content.

Gas chromatography analysis is presented in Table 2. The volume of gas present did not appear to be as great as in the preceding gassy holes; however, the gas did persist to a greater depth (838 meters) than at any previous site. It has been suggested that this presence of gas at greater depths reflects the high rate of Pleistocene sedimentation and is attributable to biogenic activity.

TABLE 2
Gas Analysis, Site 91

Core No.	Depth (m)	Methane (%)[a]
3-Top		58
3-Top	159	67
4-Top		53
4-Top	180	50
5-Middle		68
5-Middle	190	72
6-Top		67
6-Top	301	65
7-Bottom		61
7-Bottom	412	55
8-Middle		60
8-Middle	492	55
10-Top		62
10-Top	652	60
11-Middle		62
11-Middle	774	63
18-Middle		63
18-Middle	838	60

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Ewing, M., Worzel, J. L., Ericson, D. B. and Heezen, B. C., 1955. Geophysical and Geological Investigations in the Gulf of Mexico, Part I. Geophysics. **20**, 1.

Ewing, M., Ericson, D. B. and Heezen, B. C., 1958. Sediments and Topography of the Gulf of Mexico. *In* Habitat of Oil, L. Weeks (Ed.). Tulsa (Am. Assoc. Petrol. Geologists, 995.

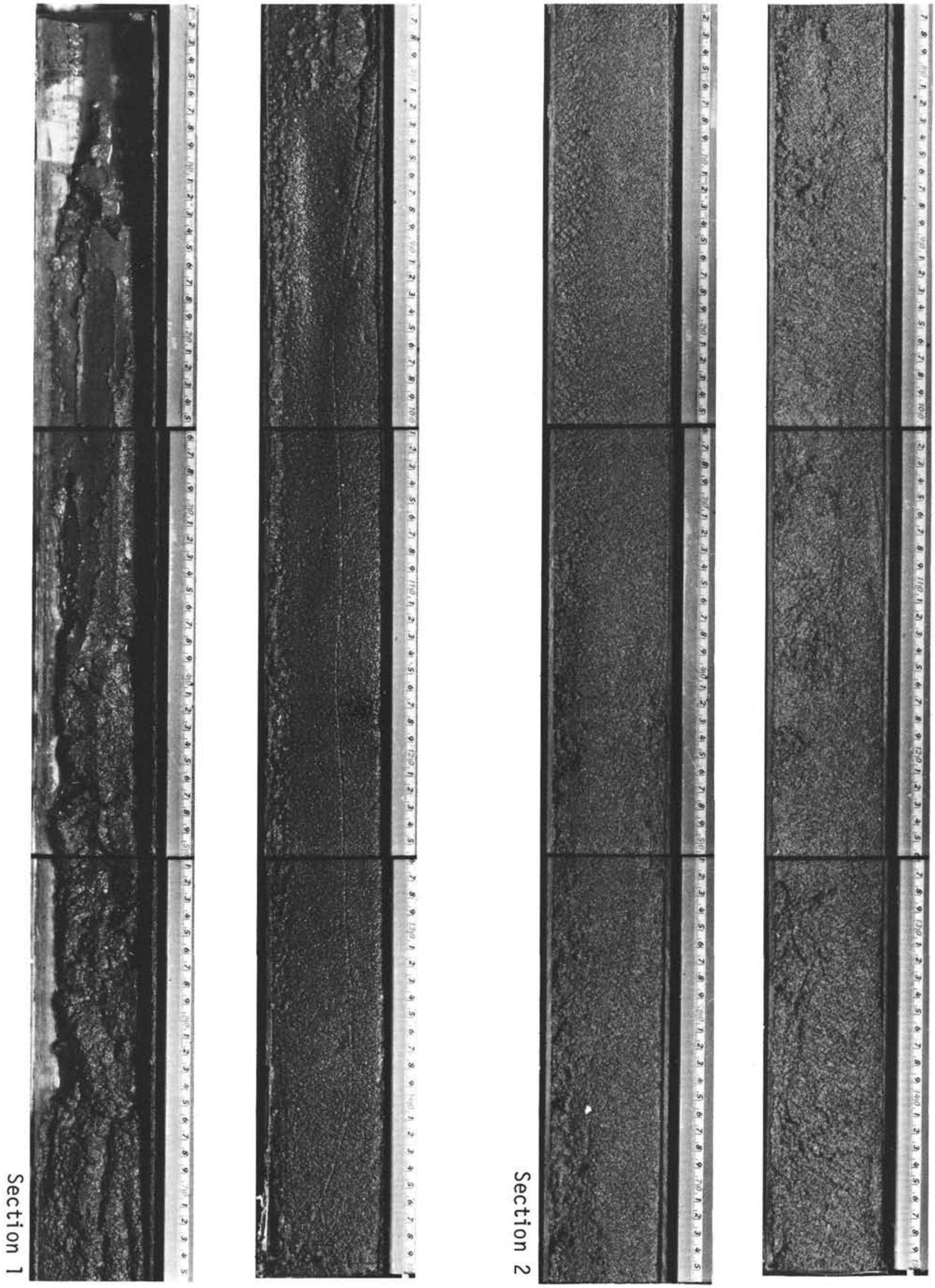


Figure 6. *Coarse-grained sediment in Core 25, Hole 91. Note that Sections 1, 2, and 3; and most of Section 4 are one turbidite layer with evident grading.*

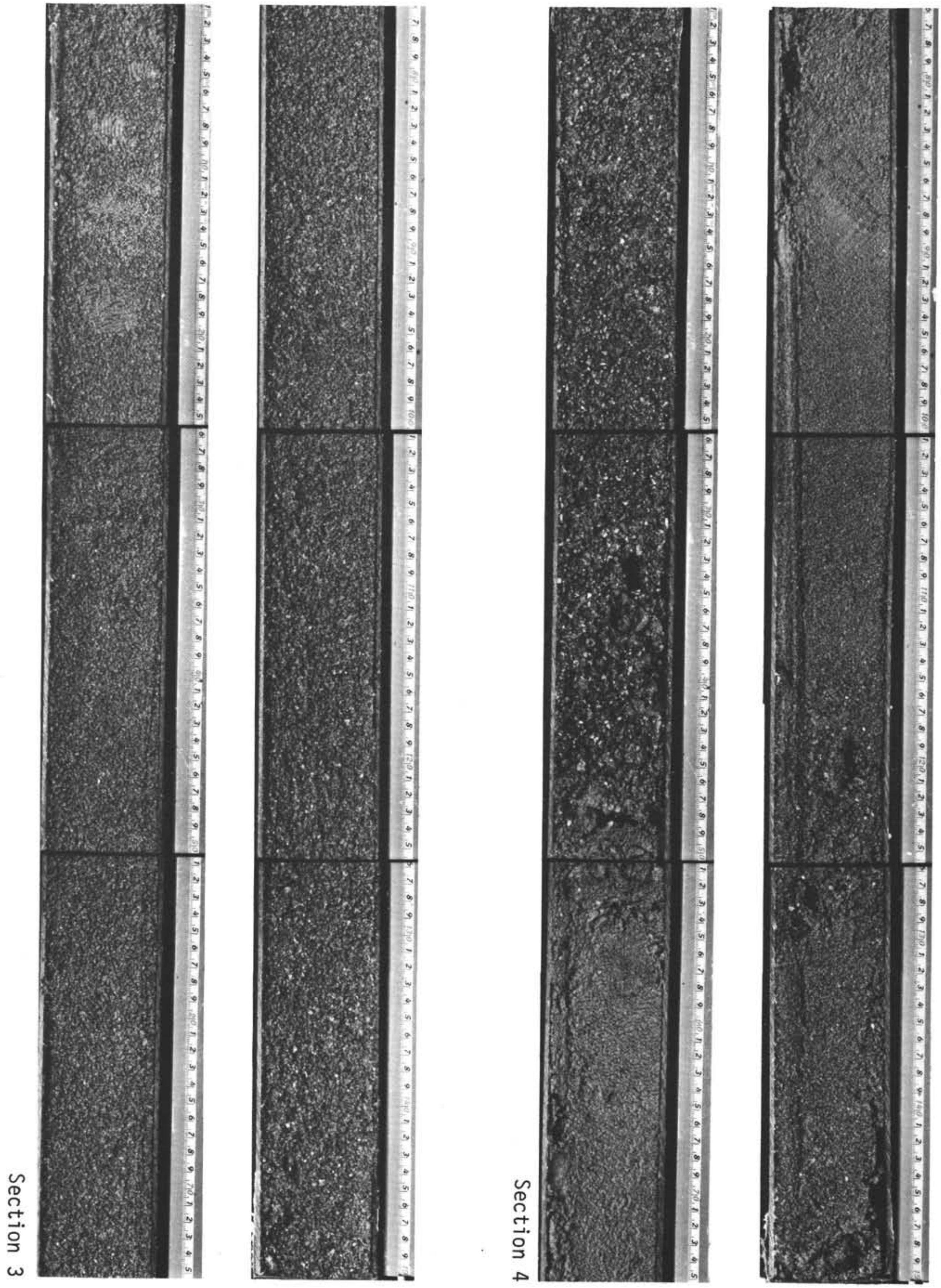
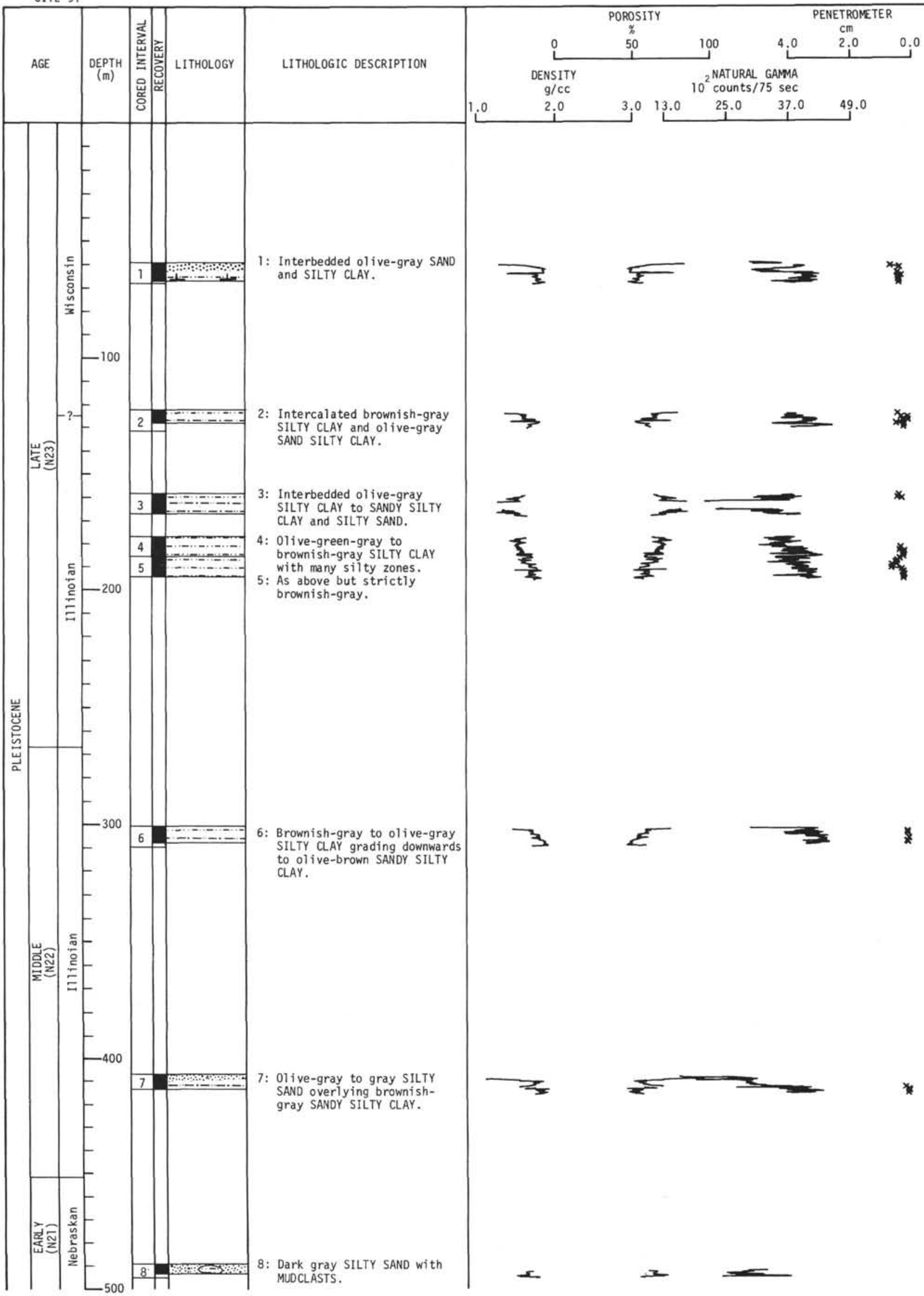
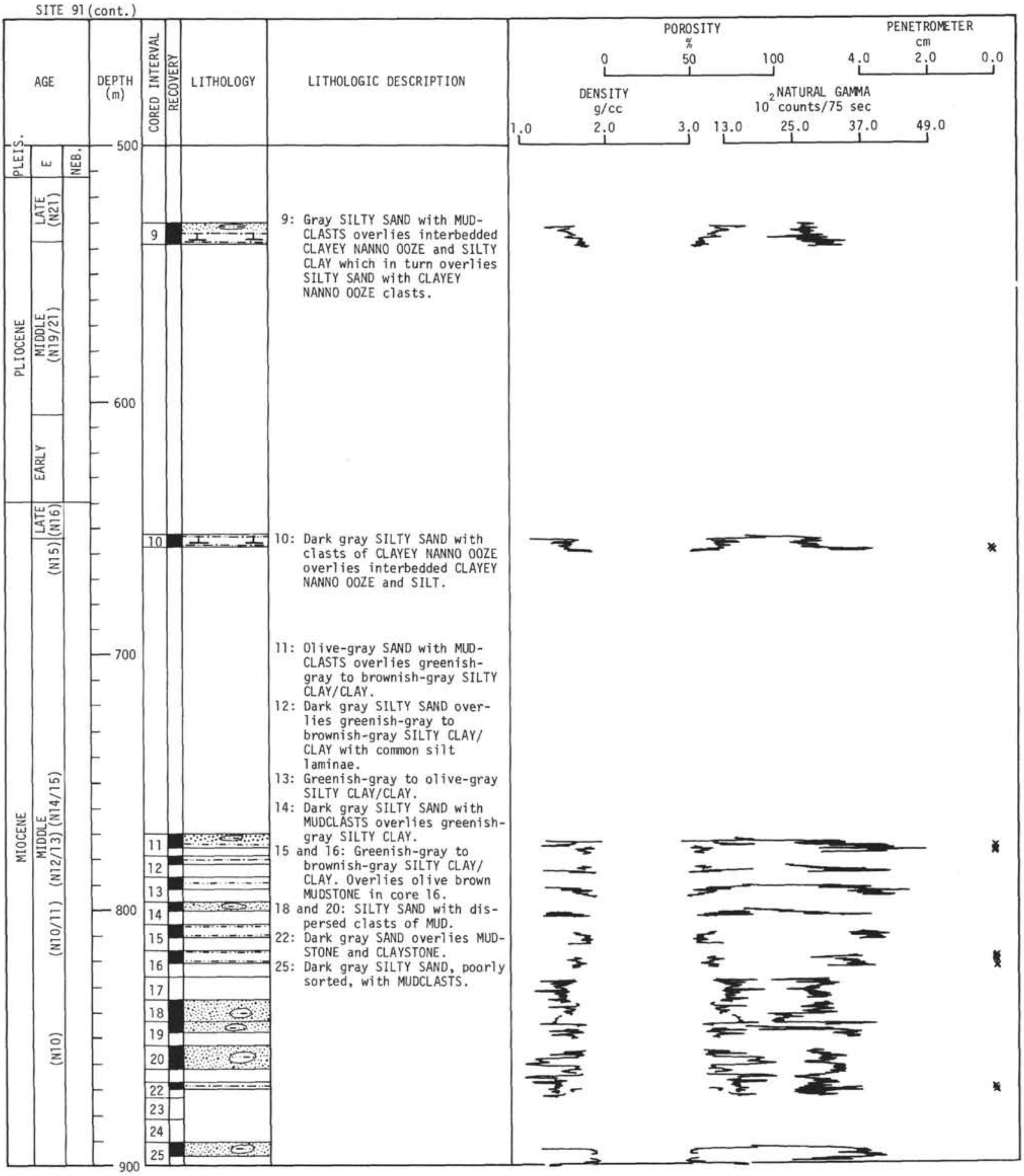


Figure 6. *(Continued).*

SITE 91


AGE
DEPTH (m)
CORED INTERVAL
RECOVERY
LITHOLOGY
LITHOLOGIC DESCRIPTION
POROSITY %
0
50
100
PENETROMETER cm
4.0
2.0
0.0
DENSITY g/cc
1.0
2.0
3.0
NATURAL GAMMA 10^2 counts/75 sec
13.0
25.0
37.0
49.0
PLEISTOCENE
LATE (N23)
MIDDLE (N22)
EARLY (N21)
Wisconsin
?
Illinoian
Illinoian
Nebraskan
100
200
300
400
500
1
2
3
4
5
6
7
8
1: Interbedded olive-gray SAND and SILTY CLAY.
2: Intercalated brownish-gray SILTY CLAY and olive-gray SAND SILTY CLAY.
3: Interbedded olive-gray SILTY CLAY to SANDY SILTY CLAY and SILTY SAND.
4: Olive-green-gray to brownish-gray SILTY CLAY with many silty zones.
5: As above but strictly brownish-gray.
6: Brownish-gray to olive-gray SILTY CLAY grading downwards to olive-brown SANDY SILTY CLAY.
7: Olive-gray to gray SILTY SAND overlying brownish-gray SANDY SILTY CLAY.
8: Dark gray SILTY SAND with MUDCLASTS.

SITE 91 (cont.)


AGE
DEPTH (m)
CORED INTERVAL
RECOVERY
LITHOLOGY
LITHOLOGIC DESCRIPTION
POROSITY %
0 50 100
PENETROMETER cm
4.0 2.0 0.0
DENSITY g/cc
1.0 2.0 3.0
NATURAL GAMMA 10^2 counts/75 sec
13.0 25.0 37.0 49.0
PLEIS.
E
NEB.
PLIOCENE
LATE (N21)
MIDDLE (N19/21)
EARLY
MIOCENE
LATE (N16)
(N15)
MIDDLE (N12/13) (N14/15)
(N10/11)
(N10)
500
600
700
800
900
9
10
11
12
13
14
15
16
17
18
19
20
22
23
24
25
9: Gray SILTY SAND with MUD-CLASTS overlies interbedded CLAYEY NANNO OOZE and SILTY CLAY which in turn overlies SILTY SAND with CLAYEY NANNO OOZE clasts.
10: Dark gray SILTY SAND with clasts of CLAYEY NANNO OOZE overlies interbedded CLAYEY NANNO OOZE and SILT.
11: Olive-gray SAND with MUD-CLASTS overlies greenish-gray to brownish-gray SILTY CLAY/CLAY.
12: Dark gray SILTY SAND over-lies greenish-gray to brownish-gray SILTY CLAY/CLAY with common silt laminae.
13: Greenish-gray to olive-gray SILTY CLAY/CLAY.
14: Dark gray SILTY SAND with MUDCLASTS overlies greenish-gray SILTY CLAY.
15 and 16: Greenish-gray to brownish-gray SILTY CLAY/CLAY. Overlies olive brown MUDSTONE in core 16.
18 and 20: SILTY SAND with dis-persed clasts of MUD.
22: Dark gray SAND overlies MUD-STONE and CLAYSTONE.
25: Dark gray SILTY SAND, poorly sorted, with MUDCLASTS.

Site 91 Hole Core 1 Cored Interval: 60-69 m

AGE: LATE PLEISTOCENE (Wisconsin)

ZONE: *Globorotalia truncatulinoides* (*Pulleniatina finalis* Subzone)

SECTION	LITHOLOGIC DESCRIPTION	SAND	SILT	CLAY
1	VOID			
1	Brecciated-mechanically disturbed.			
2	Interbedded SAND and SILTY CLAY. Former is olive-gray, horizontally laminated, sometimes cross-laminated, graded texturally silty very fine sand to sandy silt. Latter is massive to faintly laminated. Turbidite laminite.	0.0	29.0	71.0
3	Horizontally laminated clayey to silty V.F. sand.	6.7	75.4	17.9
3	Silty V.F. to F. sand (massive?-disturbed).			
3	Horizontally laminated(?), clayey V.F. sand.			
3	Silty V.F. to V.F. sand, massive?			
4	Massive silty clay.	0.6	22.2	77.2
4	Massive V.F. sand with coarse silt laminae, possibly cross laminated.			
4	Clayey V.F. sand with coarse silt laminae, possibly cross laminated.			
5	Massive silty clay.			
5	N3 laminae-fecal?			
5	Interlaminated silty clay and silty V.F. sand/sandy coarse silt.			
5	Horizontally interlaiminated silty V.F. sand/sandy coarse silt.			
6		0.1	11.2	88.7
6	Massive, sandy silty clay with scattered small patches of silt/sand.			
6	V.F. sand grading up into sandy, V. coarse silt to clayey silt.			
6	Lignite.			
Core Catcher	N3 Laminae.			

Site 91 Hole Core 2 Cored Interval: 123-132 m

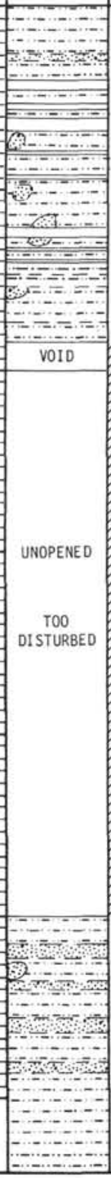
AGE: LATE PLEISTOCENE (Wisconsin)

ZONE: *Globorotalia truncatulinoides* (*Pulleniatina finalis* Subzone)

SECTION	LITHOLOGIC DESCRIPTION	SAND	SILT	CLAY
1	VOID			
1	Slightly gas expanded.			
2	SILTY CLAY. Brownish-gray (5YR4/1); massive, strongly disturbed with zones of gray-red (10YR4/2) silty clay.			
3	SANDY SILTY CLAY. Olive gray (5Y4/1); massive with speckles of coarse silt/V.F. sand scattered throughout - probably microburrows.			
4		0.0	36.7	63.2
4	Horizontally to crosslaminated sandy to clayey silt with rare silty V.F. sand laminae.			
4	Dominantly horizontally laminated silty V.F. sand grading up into muddy V.F. sand and subsidiary sandy coarse silt.	0.5	15.8	83.7
5	SILTY CLAY. 5YR4/1; massive, N3 faecal microburrow-fill. Laminite-turbidite.			
Core Catcher				

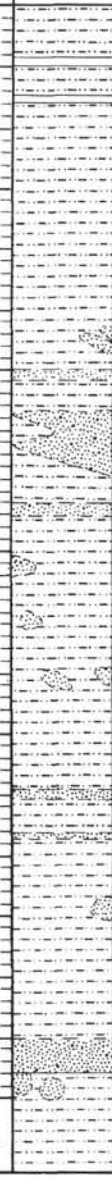
Site 91 Hole Core 3 Cored Interval: 159-168 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
LATE PLEISTOCENE (Illinoian)	*Globorotalia truncatulinoides (Pulleniatina finalis Subzone)*	1	0.5, 1.0				Gas expanded. VOID			
							SILTY CLAY to SANDY SILTY CLAY Olive-gray (5Y4/1), with random patches of coarse silt/V.F. sand - probably micro-burrow fill? Occasional thin quartzose silt laminae, highly deformed.	0.2	21.5	78.3
		2		VOID			VOID			
		3		UNOPENED			NOT OPENED - Assumed to be as above and below.			
		4		TOO DISTURBED						
		5					Laminite.			
		6					As above. Interbedded with:	4.8	58.8	36.4
							SILTY SAND Lamination largely disrupted. Occasional lamination and burrow-fill of faecal (N3) stain.			
		Core Catcher								



Site 91 Hole Core 4 Cored Interval: 177-186 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
LATE PLEISTOCENE (Illinoian)	*Globorotalia truncatulinoides (Pulleniatina finalis Subzone)*	1	0.5, 1.0				Gas expanded.			
							SILTY CLAY Olive-green-gray (5Y4/1-5GY4/1); massive, rarely burrowed(?). Many silty zones probably originally laminae/bands of silt. Scattered fecal (N3) stain. VOID			
		2						1.1	41.8	57.1
		3						2.8	33.5	63.7
		4						0.3	50.6	49.0
							Laminite.	0.0	36.8	63.2
		5					As above. Brownish-gray, massive. Ideally and exturally graded sand bed near base. Transitional color change to 5YR4/1.	0.3	15.7	84.0
		6					Interlaminated sandy coarse silt and silty clay. Cross laminated. Horizontally laminated, silty, V.F. sand, sandy coarse silt and clayey silt.			
		Core Catcher								



Site 91 Hole Core 5 Cored Interval: 186-195 m

AGE: LATE PLEISTOCENE (Illinoian)

ZONE: *Globorotalia truncatulinoides* (? *Pulleniatina finalis* Subzone)

SECTION	LITHOLOGIC DESCRIPTION	SAND	SILT	CLAY
1	SILTY CLAY Brownish-gray (5YR4/1); massive to faintly laminated. Silt-filled burrows. Thin quartzose silt laminae strongly disrupted by drilling. Irregular laminae and stained zones of fecal/FeS (N3-4).	0.4	32.6	67.0
2		0.0	27.5	72.4
3	Laminite.	0.0	45.7	54.3
4	Sandy coarse silt/silty V.F. sand. Horizontal lamination?			
5	Silty V.F. sand grading up into sandy coarse silt and clayey silt. Alternating laminae/bands. 5YR4/1 with subsidiary 5YR3/1. Faintly laminated 5YR3/1 to dominant.	0.0	29.7	70.3
6	VOID Horizontally laminated clayey silt. Sandy silty clay with microburrows and silt laminae. 5YR4/1 is dominant. Faintly laminated.			
Core Catcher				

Site 91 Hole Core 6 Cored Interval: 301-310 m

AGE: MIDDLE PLEISTOCENE (Illinoian)

ZONE: *Globorotalia truncatulinoides* (? *Globoquadrina dutertrei* Subzone)

SECTION	LITHOLOGIC DESCRIPTION	SAND	SILT	CLAY
1	SILTY CLAY Brownish-gray to olive-gray; unburrowed; unfossiliferous. Finely laminated (alternating laminae bands of 5YR3/1 and 5Y3/1. VOID	0.0	21.2	78.8
2	Very faintly laminated (5Y3/1 is dominant).	0.0	22.0	78.0
3	Faintly laminated. Silt burrow-fill? VOID Laminite.	0.0	26.5	73.5
4	Bands of sandy silty clay. Alternating bands of burrowed sandy silty clay and silty clay.	0.0	41.0	59.0
5	SANDY SILTY CLAY Olive brown with rare laminae of silty clayey sand. VOID Tube collapsed.			
Core Catcher				

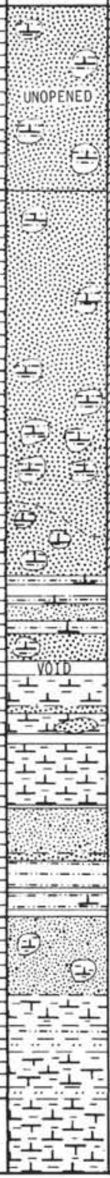
Site 91 Hole Core 7 Cored Interval: 407-413 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE PLEISTOCENE (Illinoian)	*Globorotalia truncatulinoides* (? *Globoquadrina dutertrei* Subzone)	1	0.5, 1.0	VOID			Slightly gas bearing. Disturbed mechanically and by gas bubbles.			
							"Cave"?	26.4	66.6	6.9
							SILTY SAND Olive gray to gray (5Y4/1). Sand is very fine to moderately sorted (quartzose) fine. Some carbonaceous debris and rare small mud clasts.			
		2		VOID				28.2	65.5	6.3
							Base of graded unit?			
		3					Base of graded unit?	54.9	41.2	3.9
							Zone of mixed mud-clasts and sand matrix. Either jetted/cave.			
		4					SILTY CLAY 5Y3/1 and 5YR4/1; faintly laminated. Microburrows(?) with sand-fill.	1.4	38.4	60.2
							VOID			
							Interlaminated coarse silt and silty clay.			
		5					SANDY SILTY CLAY Brownish-gray (5YR4/1); moderately burrowed with silt/sand burrow-fill (5Y8/1). Faint silt laminations. Pyrite concretions.	0.5	25.1	74.4
							VOID			
		Core Catcher					Turbidite(?)-laminite.			

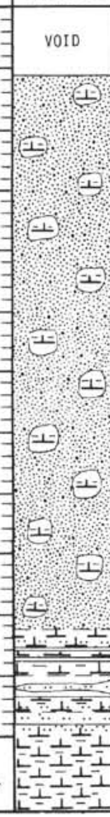
Site 91 Hole Core 8 Cored Interval: 490-495 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
EARLY PLEISTOCENE (Nebraskan)	*Globorotalia truncatulinoides* (*Globorotalia tosaensis* Subzone)	1	0.5, 1.0				Brecciated-mechanically disturbed.	47.9	34.2	17.9
							SILTY SAND with MUDCLASTS Former is dark-gray N4-6); latter is 5G7/1-6/1 and nanno-bearing.			
		2					VOID	54.7	29.4	15.9
							Mottled with N5 stain. N6, brecciated as above.			
							Nanno-bearing silty clay; quartz silt laminae. 5Y8/1 with 5Y6/1 and N5. Pyrite burrow fill. Graded silty V.F. sand to coarse silt.			
		Core Catcher					Turbidite-hemi-laminite.			

Site 91 Hole Core 9 Cored Interval: 530-538 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	SAND	SILT	CLAY
LATE PLIOCENE	*Pulleniatina obliquiloculata*	1	0.5, 1.0				Not opened - too disturbed. Lithology assumed to be as below. Brecciated - mechanically disturbed.			
		2				—	SILTY SAND with MUDCLASTS Former is gray (N4); very fine; poorly sorted. Latter is common and nanno-bearing. Turbidite-hemi-laminite.	53.0	36.7	10.4
		3				—	As above. Mudclasts more abundant. Possibly "jetted" interbeds.	74.8	20.3	4.8
		4				—	Interbedded CLAYEY NANNO OOZE and SILTY CLAY Former is strongly burrowed. Latter is nanno-bearing. Thin beds of quartzose sand/bands of quartzose silt. VOID	57.9	23.4	18.7
		5				—	As above. Former is greenish-gray (5G7/1); laminated, moderately to sparsely burrowed and slightly foraminiferal. VOID	1.9	14.2	83.9
		6				—	SILTY SAND with CLAYEY NANNO OOZE clasts. Former is gray, poorly sorted. Clasts are rare.	54.5	29.4	16.1
		Core Catcher					Clayey NANNO ooze and silty clay as above. 5G7/1 with minor 6/1, 5GY6/1, and N3.			

Site 91 Hole Core 10 Cored Interval: 652-658 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	SAND	SILT	CLAY
MIDDLE MIOCENE	N16	1	0.5, 1.0				Brecciated-mechanically disturbed.			
		2				—	SILTY SAND with clasts of CLAYEY NANNO OOZE Former is dark gray (N4), very fine and poorly sorted. Latter is 5G6/1.	18.3	51.6	30.1
		3								
		4				—	VOID Interbedded CLAYEY NANNO OOZE and SILT Former is greenish-gray (5G5/1-5B5/1); moderately burrowed. Latter is graded, sometimes cross laminated, quartzose and coarse with some thin graded silt laminae as discrete units.	21.2	62.4	16.4
	N15	Core Catcher					Laminite-turbidite?			

Site 91 Hole Core 11 Cored Interval: 770-779.2 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	?N14/N15	1	0.5, 1.0	UNOPENED			Slightly gas expanded. Section 1 unopened - too disturbed. Assumed too be as below. Brecciated-mechanically disturbed.			
		2					SAND with MUDCLASTS Former is olive-gray (5Y4/1), very fine to fine and quartzose. Latter is (5G5/1).	77.6	17.4	4.9
		3					VOID SILTY CLAY/CLAY Greenish-gray to brownish-gray (5G5/1 and 5YR4/1 dominant); vaguely to moderately laminated; unfossiliferous to slightly nanno-bearing. Occasional thin silt lamination. Note zeolite-ash unit.	2.7	20.9	76.5
		4						0.0	16.4	83.6
		Core Catcher					Appears highly montmorillonitic. Hemi-laminite.			

Site 91 Hole Core 12 Cored Interval: 779.2-788.4 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N14/N15	1	0.5, 1.0	UNOPENED			Slightly gas expanded. Unopened-too disturbed; assumed to be as below. Homogenized-disturbed.			
		2					SILTY SAND Dark gray (N4) with brownish hue; moderate to poorly sorted, silty very fine sand.			
		3					VOID SILTY CLAY/CLAY Greenish-gray to brownish-gray (5G5/1 and 5YR4/1 dominant); vaguely to moderately laminated (color laminated); moderately burrowed; unfossiliferous with common thin silt laminae. VOID			
		Core Catcher								

Site 91 Hole Core 13 Cored Interval: 788.4-797.6 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N12/N13	1	0.5, 1.0	VOID			SILTY CLAY/CLAY Greenish-gray to olive-gray; vague to faintly (color) laminated, micro-mottled; moderately burrowed; unfossiliferous with rare silt laminae.			
		2				—		3.6	30.2	66.2
						—	CLAY Olive-gray; slightly silty. Appears slightly coarser than greenish-gray clay.	1.4	18.3	80.3
		3					Hemi-laminite.			
		Core Catcher								

Site 91 Hole Core 14 Cored Interval: 797.6-806.8 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N10/N11	1	0.5, 1.0	UNOPENED			Not opened-too disturbed. Assumed to be as below. Brecciated-mechanically disturbed "cave"?			
		2					SILTY SAND with MUDCLASTS Former is dark gray (N4), poorly sorted and very fine. Latter is greenish-gray.			
		Core Catcher					SILTY CLAY/CLAY Greenish-gray (5G5/1 with subsidiary 5Y4/1, N4, and 5G4/1); vaguely laminated; moderately burrowed; unfossiliferous. Hemi-laminite?			

Site 91 Hole Core 15 Cored Interval: 806.8-816.0 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N9/N10	1	0.5, 1.0				SILTY CLAY/CLAY Greenish-gray to brownish-gray (color laminated); vaguely to faintly laminated; moderately to strongly burrowed. Occasional rare silt-filled burrows. Few quartz silt laminae. N3-N5 fecal stain throughout.			
		2				—		1.0	35.5	63.5
							As above. More dominantly 5G6/1. Increase in abundance by qtz silt laminae.			
							As above. Fewer silt laminae.			
		3				—		42.4	9.9	47.7
							Hemi-laminite-laminite.			
		Core Catcher								

Site 91 Hole Core 16 Cored Interval: 816-825.2 m

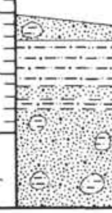
AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N9/N10	1	0.5, 1.0	VOID			SILTY CLAY/CLAY Greenish-gray to brownish-gray color laminated (5G5/1 with 5YR6/1, 5G7/1, 5Y7/1, stained with N3-N5); vaguely to faintly laminated; moderately to strongly burrowed. Rare silt filled burrows.			
							Laminite.			
		2				—		0.9	27.0	72.1
							VOID			
							5Y4/1-3/1 Clayey silt with silty clay laminae/burrow fill.			
		3				—	Poorly sorted sandy silt/sandy silty clay.	9.1	55.4	35.5
							Pyritic silty mudstone.			
							MUDSTONE Olive-brown (5Y3/1 with subsidiary 5G5/1 5GY5/1 color laminations); well laminated; with subsidiary claystone.			
		Core Catcher					Clayey silt - cross laminated at top.			

Site 91 Hole Core 17 Cored Interval: 825.2-834.4 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N10	1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0	UNOPENED			Sections not opened; too disturbed. Apparently, the major lithology is SILTY CLAY.			

Site 91 Hole Core 18 Cored Interval: 834.4-843.6 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N9/N10	1, 2, 3, 4, 5	0.5, 1.0	UNOPENED			Upper five sections not opened - too disturbed. No description available.			
		5					SILTY SAND with dispersed MUDCLASTS			
		6		SLURRY			Brecciated-disturbed.			
		6					5Y5/1 dark olive-brown; carbonaceous debris-rich; very poorly sorted silt/silty clayey V.F. sand grading up into clayey silt. Cross laminations at top? Horizontal laminations			
		6					Carbonaceous, poorly sorted silty medium sand grading up to sandy silt.	0.2	81.9	17.9
		6					Sandy mudstone.			
		Core Catcher					5Y5/1 silty sand to sandy silt. Dispersed mudclasts throughout.			



Site 91 Hole Core 19 Cored Interval: 843.6-852.8 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N9/N10	1	0.5	VOID			Core greatly disturbed and not opened.			
			1.0	UNOPENED			Major lithology apparently is silty clay and silty sand.			
		2								
		3								
		Core Catcher								

Site 91 Hole Core 20 Cored Interval: 852.8-862.0 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N9/N10	1	0.5	UNOPENED			NOTE: Core 19 not cut - too disturbed.			
			1.0				Section 1 not cut - too disturbed.			
							Disturbed throughout - "cave"?			
		2					SILTY SAND with scattered clasts of SILTY CLAY and SILTY CLAYEY SAND Sand is dark gray (N4); poorly sorted; fine to fine/medium. Mud is 5Y4/1.	84.9	10.6	4.5
		3								
		4		UNOPENED			Sections 3,4 and 5 not opened-too disturbed assumed to be as above and below.			
		5								
		6					As above. Fine to medium grade with some coarse components.	74.9	14.5	10.6
		Core Catcher								

Site 91 Hole Core 21 Cored Interval: 862-866 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N10	1	0.5, 1.0				Core not opened; too disturbed. Apparently, silty clay, sand, and mudstone.			
		2		UNOPENED						
		3								
		4								
		5		UNOPENED						
		6								
		Core Catcher								

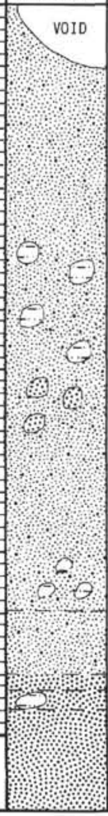
Site 91 Hole Core 22 Cored Interval: 862.0-866.0 m

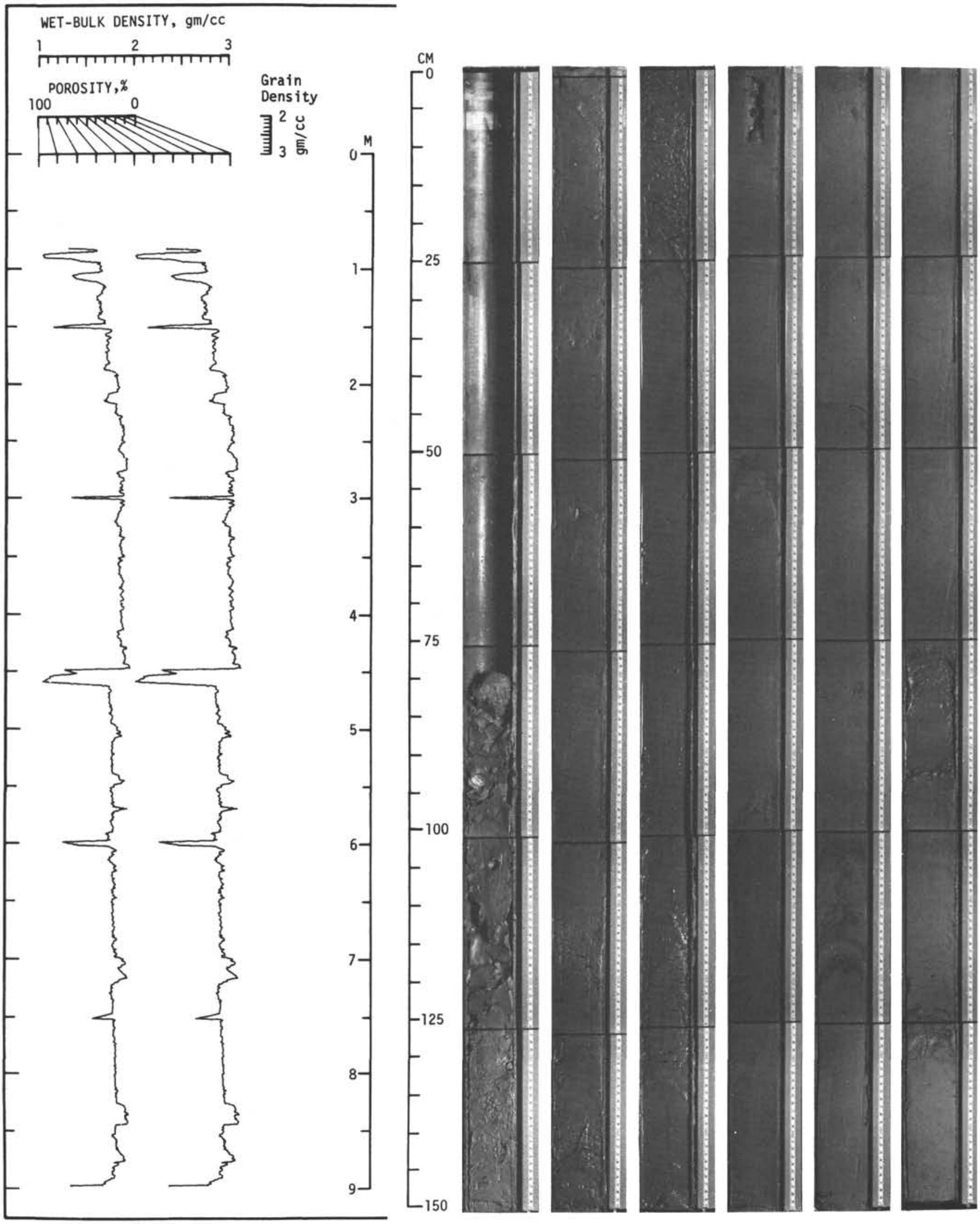
AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N9/N10	1	0.5, 1.0				NOTE: Core 21 not cut - too disturbed Mechanically disturbed "cave"?	84.3	8.0	7.6
							SAND Dark gray (N4); quartzose, terrigenous.			
		2					MUDSTONE and CLAYSTONE Vaguely color laminated (5G6/1-7/1,5GY6/1, 5Y6/1,N3); moderately to strongly burrowed/ microburrowed.	2.1	25.2	72.7
							Laminite-turbidite(?) 5Y4/1 with minor laminae of 5B5/1 and 5GY8/1 (clay).			
		Core Catcher								

Site 91 Hole Core 23 Cored Interval: 872-881.2 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N10	Core Catcher					Core Catcher only. Turbidite sands and silts.			

Site 91 Hole Core 25 Cored Interval: 890.4-899.6 m

AGE	ZONE	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION	GRAIN SIZE WEIGHT % SAND	SILT	CLAY
MIDDLE MIOCENE	N9/N10	1	0.5 1.0	VOID 			NOTE: Cores 23 and 24 not opened - too disturbed. Possibly entire barrel mechanically disturbed. SILTY SAND Dark gray (N3-4); quartzose, terrigenous; fine to medium. Poorly sorted.	95.6	2.2	2.2
		2						96.1	2.1	1.7
							As above. Fine to medium to medium/coarse. Rare mudstone clasts.			
							Clasts of V.F. sand.			
		3						97.7	0.7	1.6
							Medium to coarse/very coarse at base. Very poorly sorted.			
							Section 4 appears less disturbed. Grading suggests good sample coarse sand to pebbly very coarse sand with mudclasts up to 15 mm and rock grains to 5 mm.			
		4					Silty, V.F. to fine sand grading down to: Medium sand to pebbly coarse sand. Quartz grains to 4 mm. Mudclasts to 10 mm. Noticable shell debris in coarser units.			
		Core Catcher								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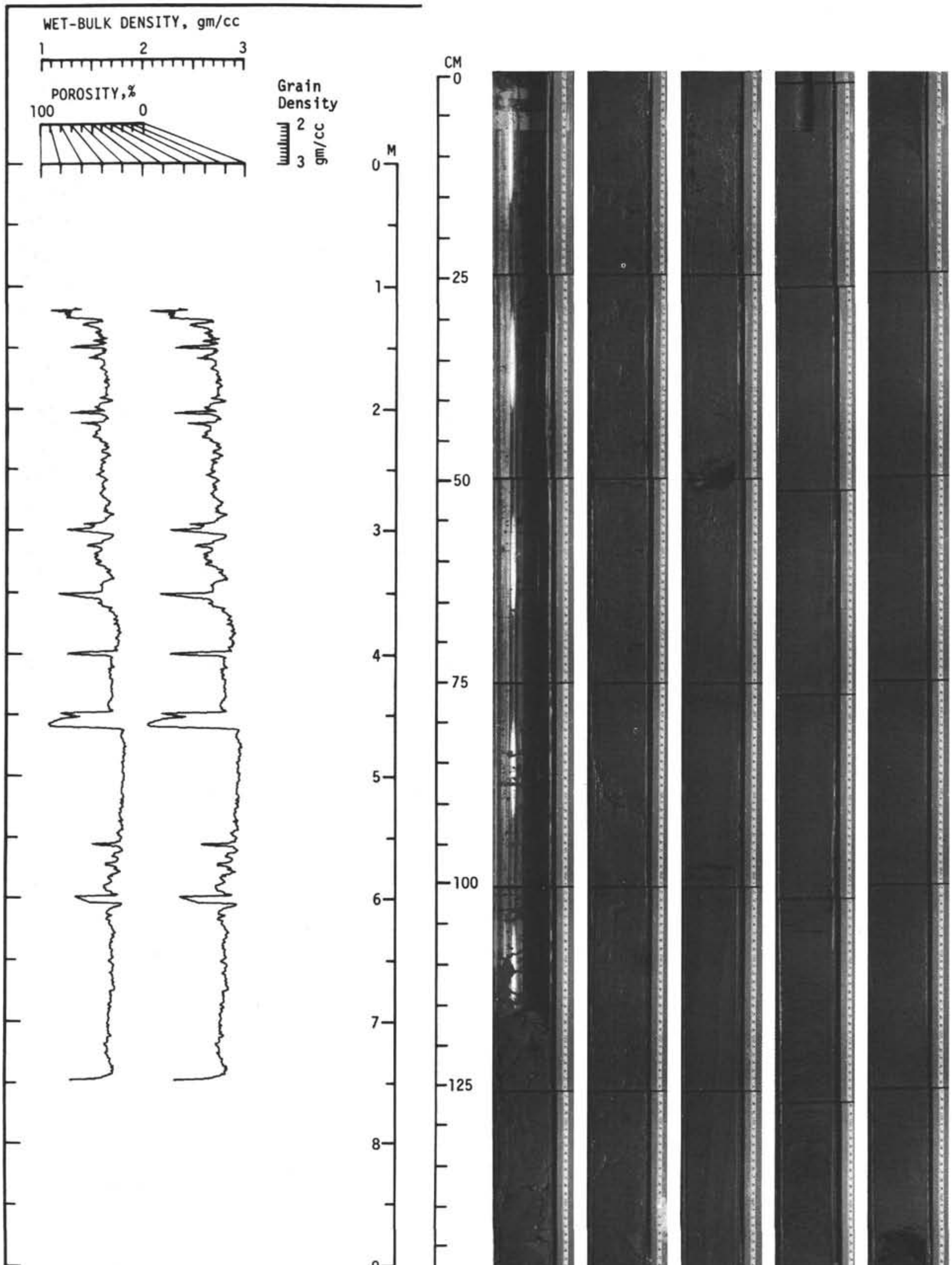
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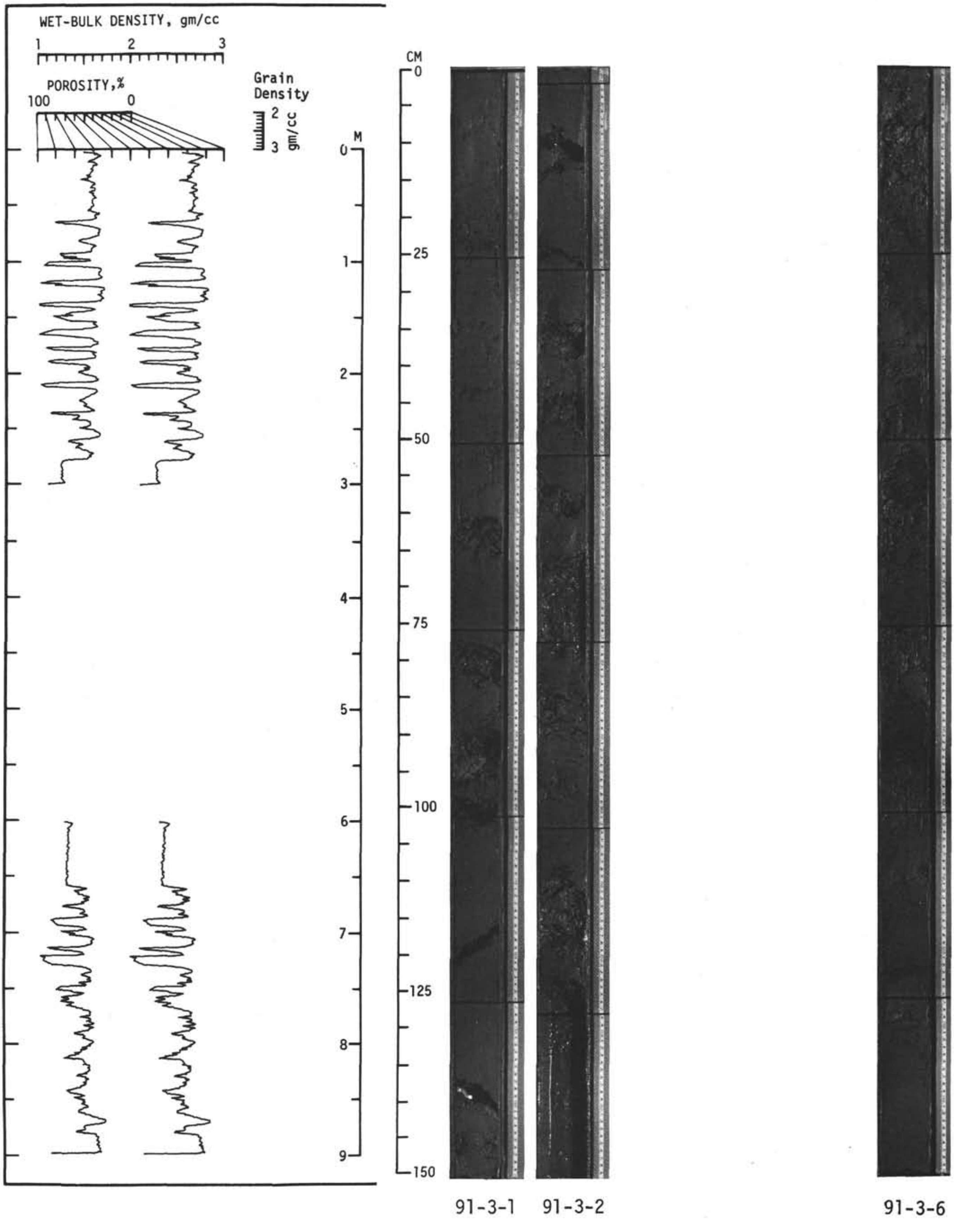
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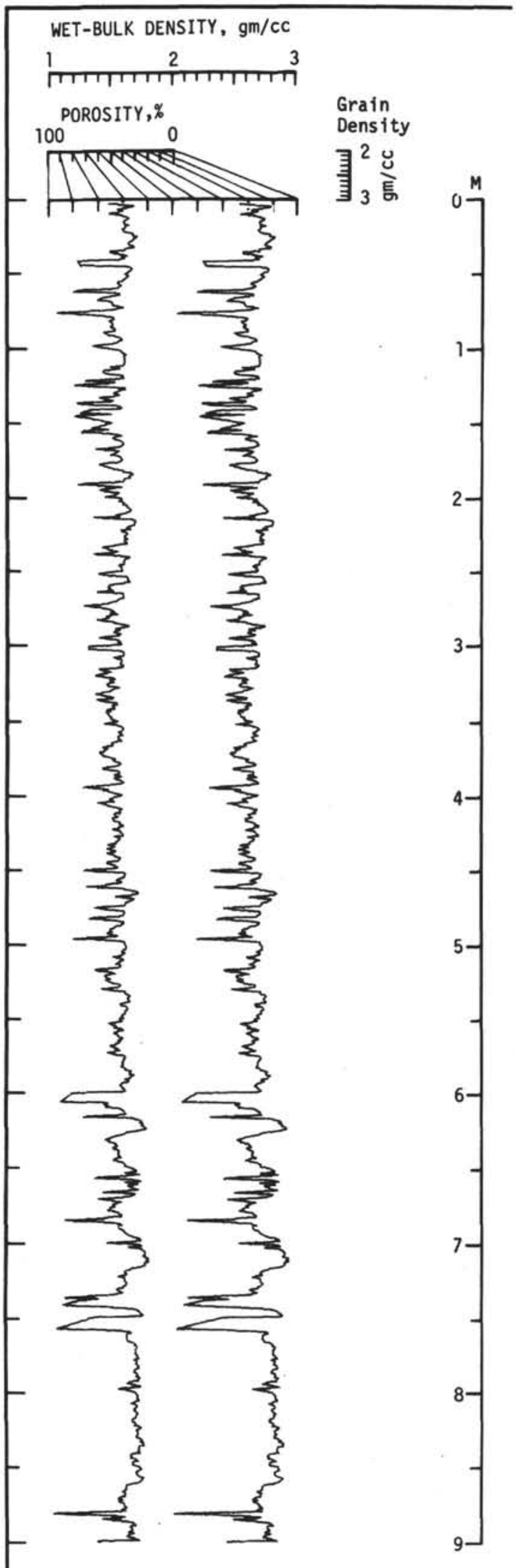

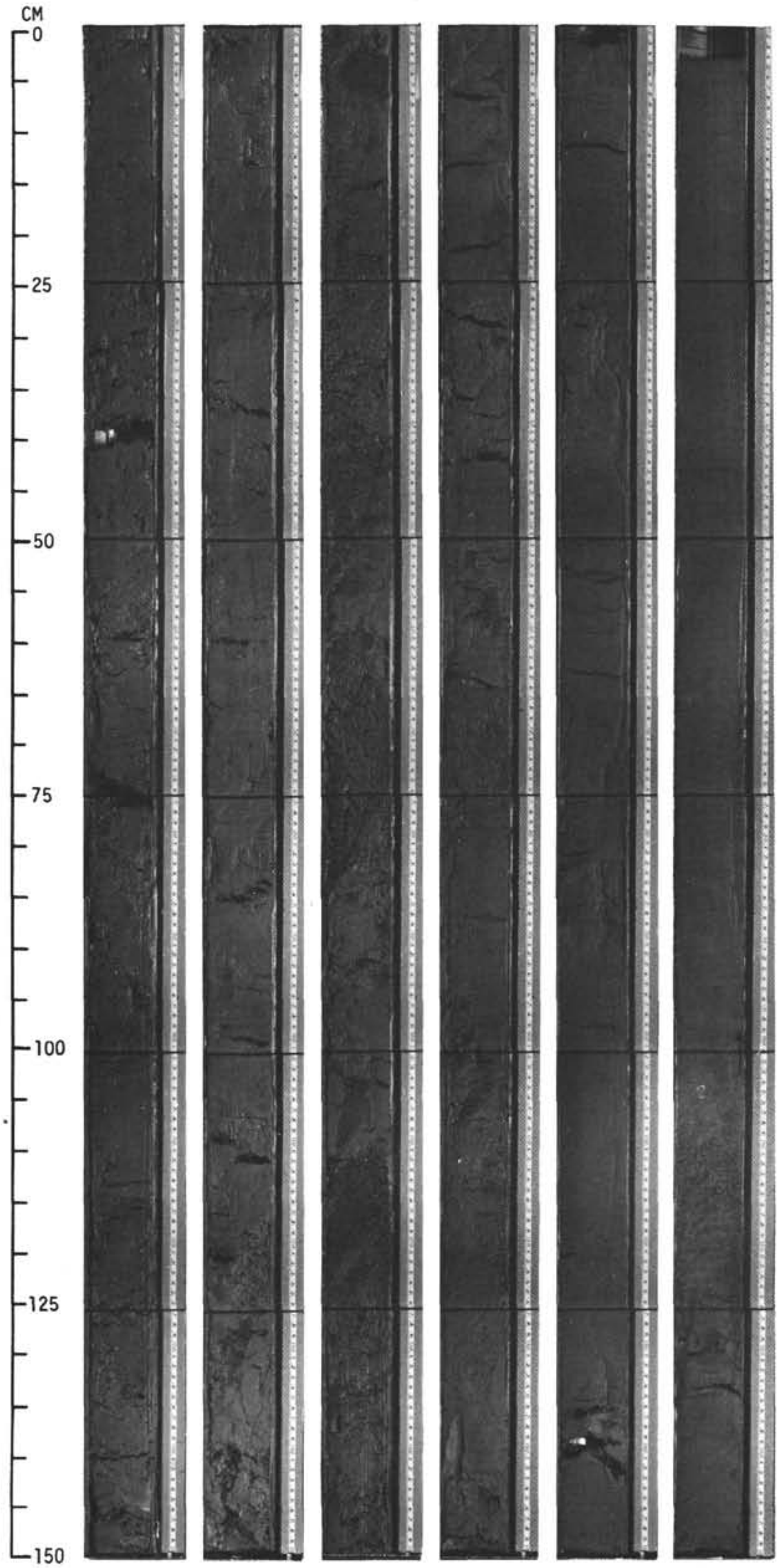

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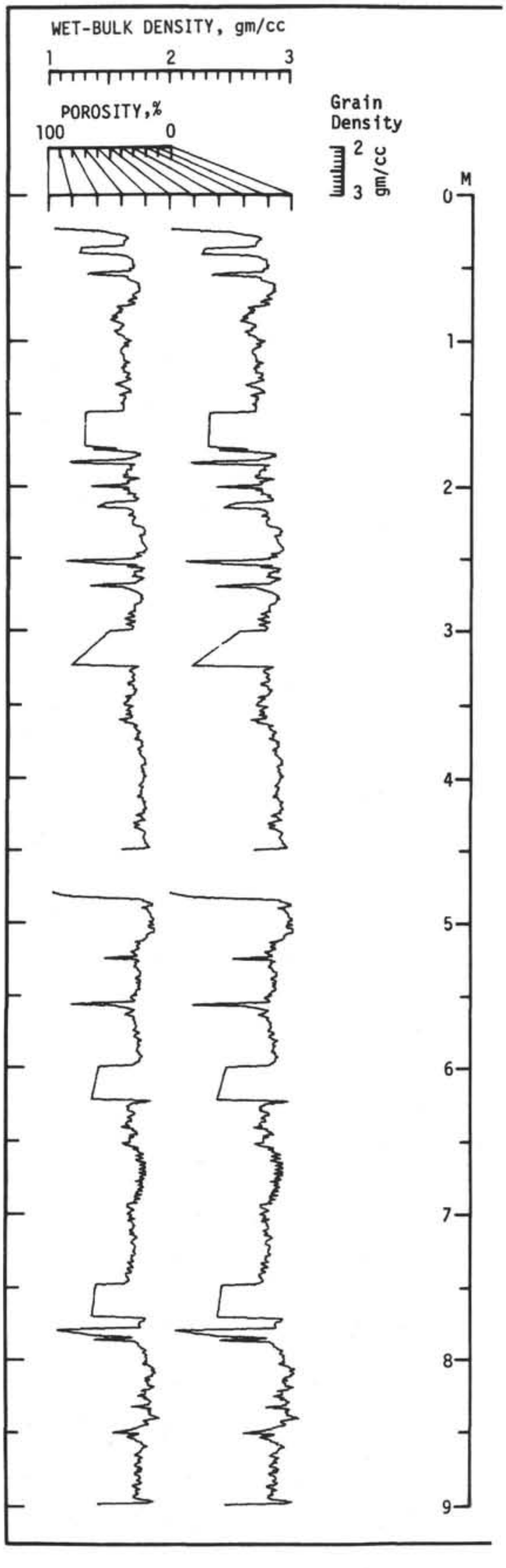

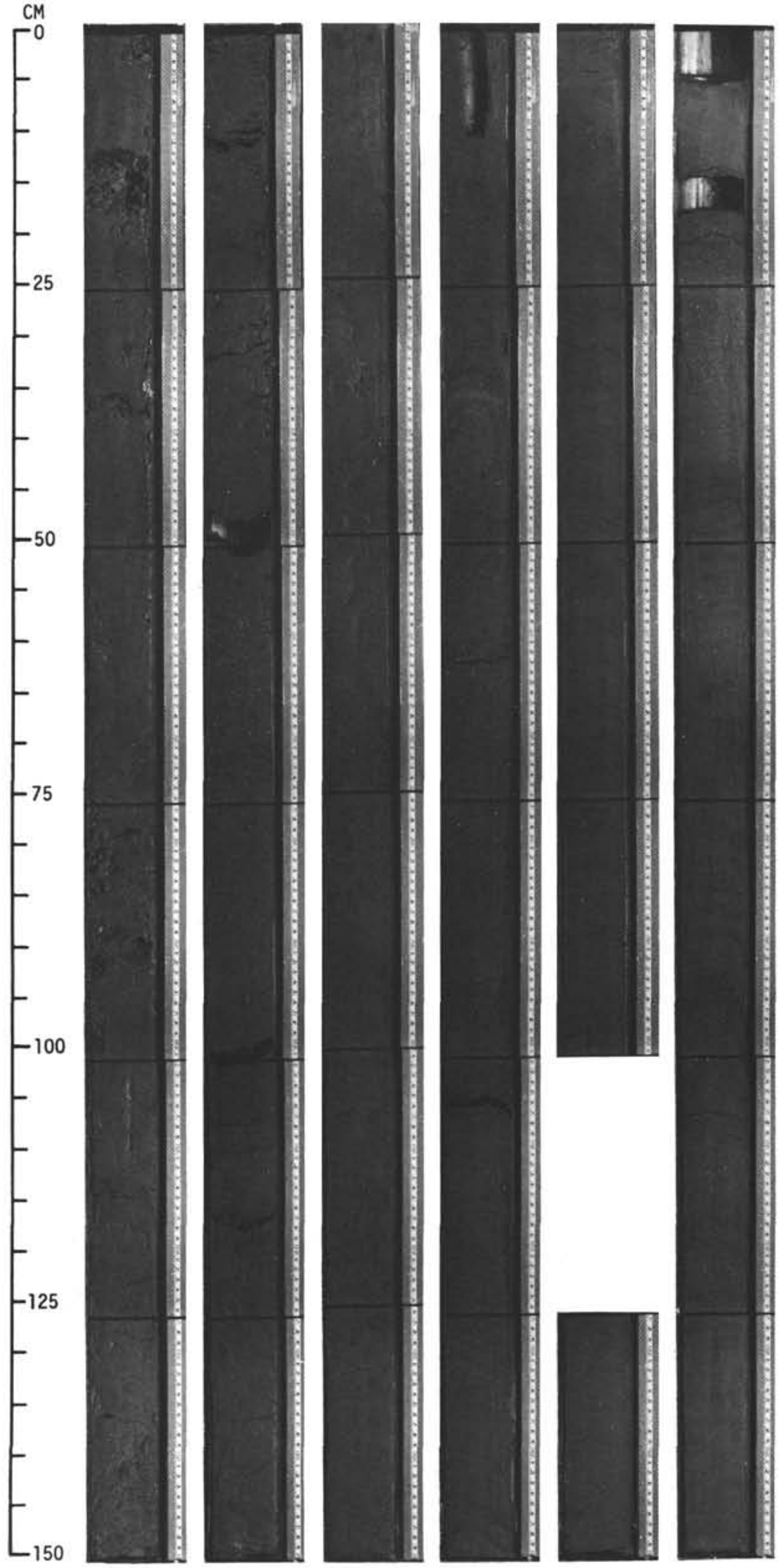

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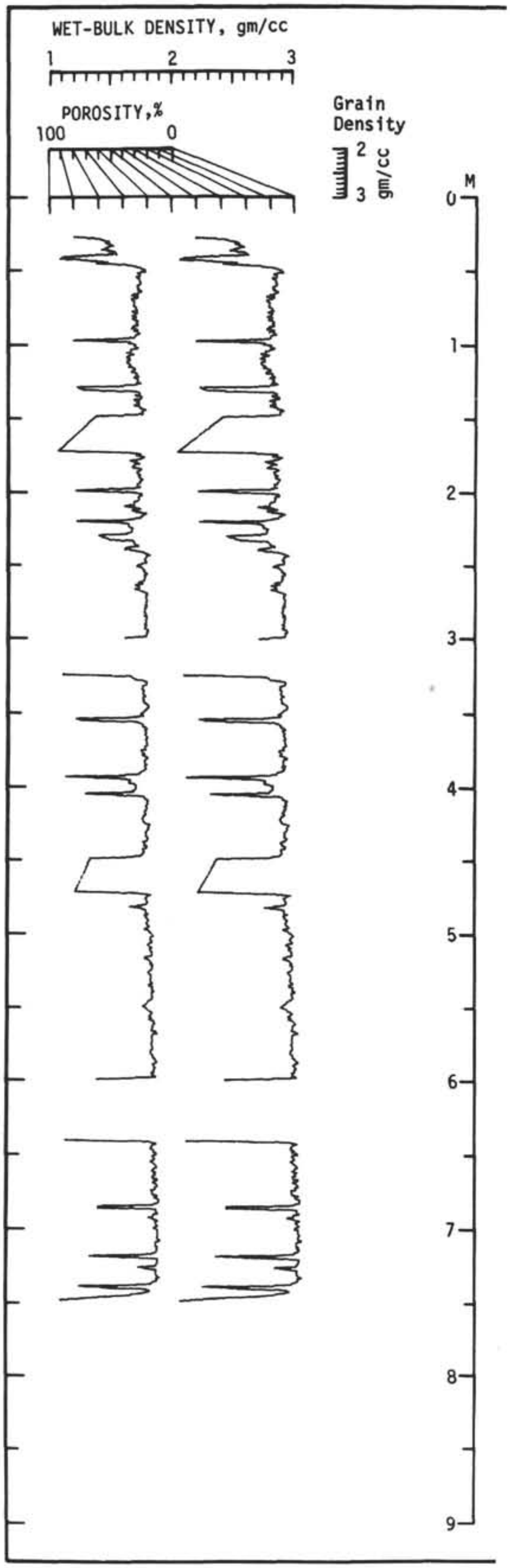
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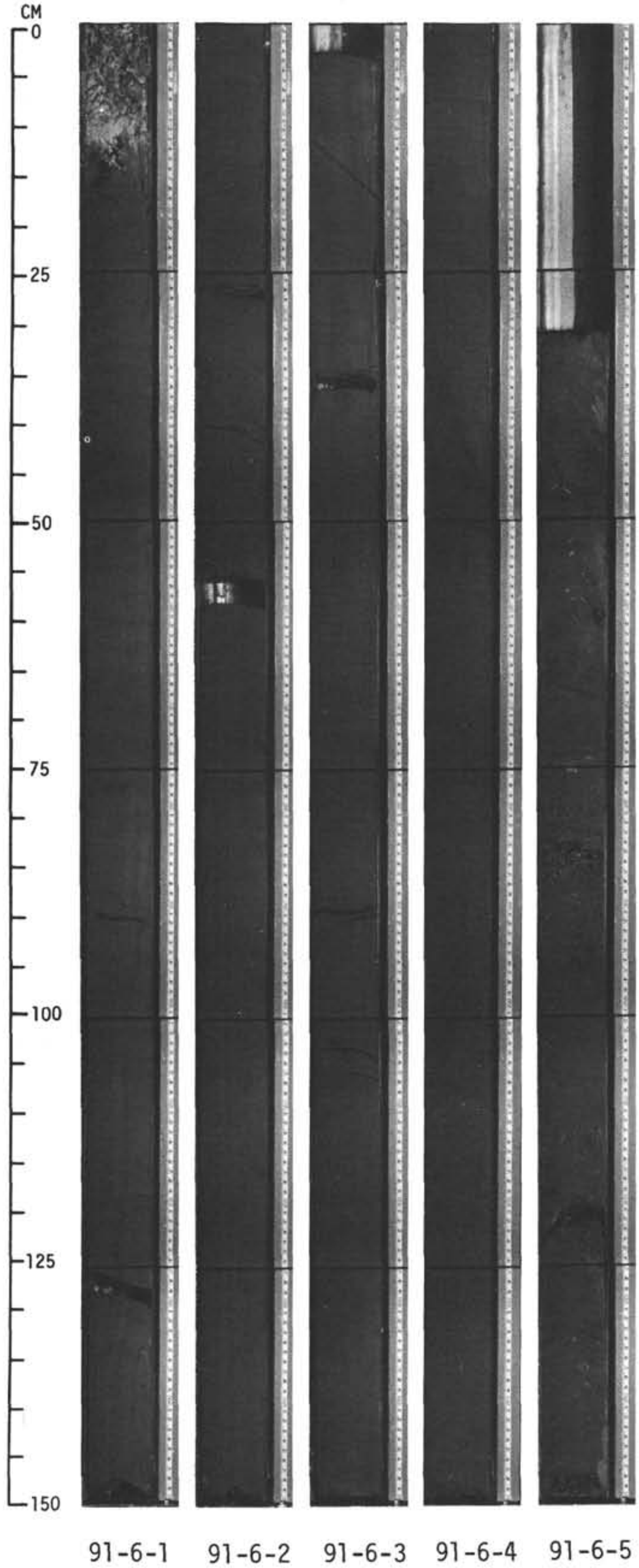
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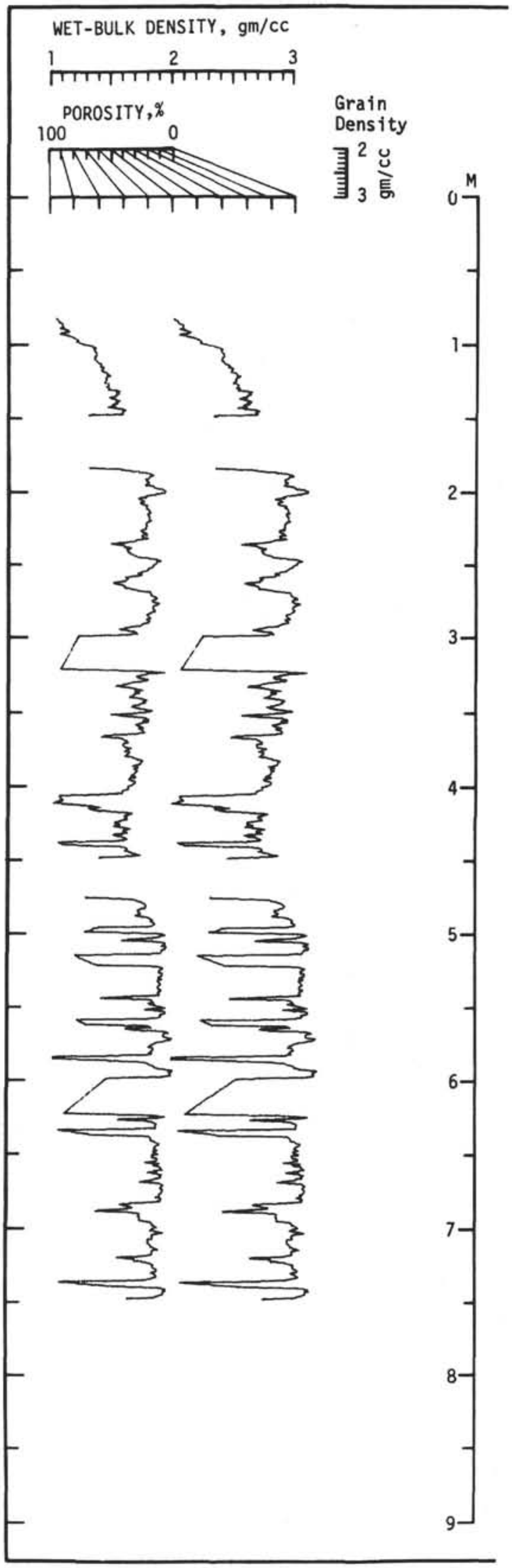
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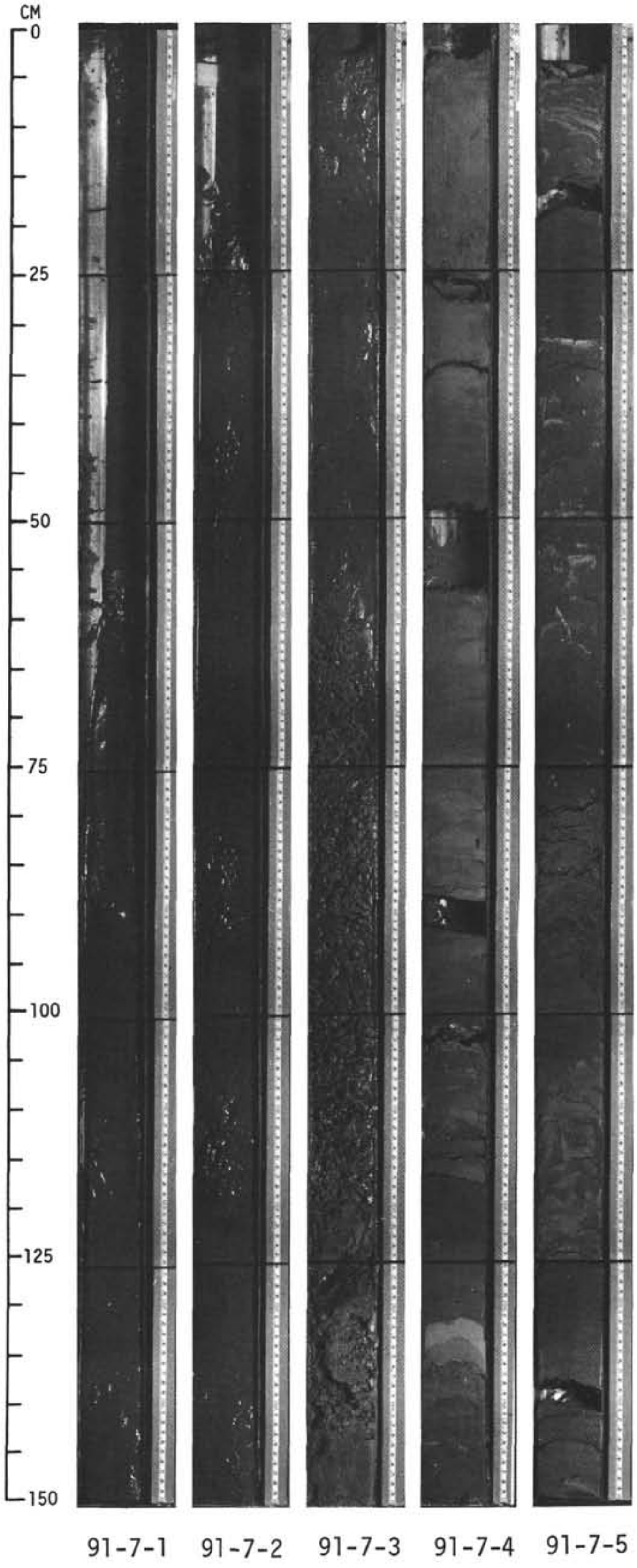
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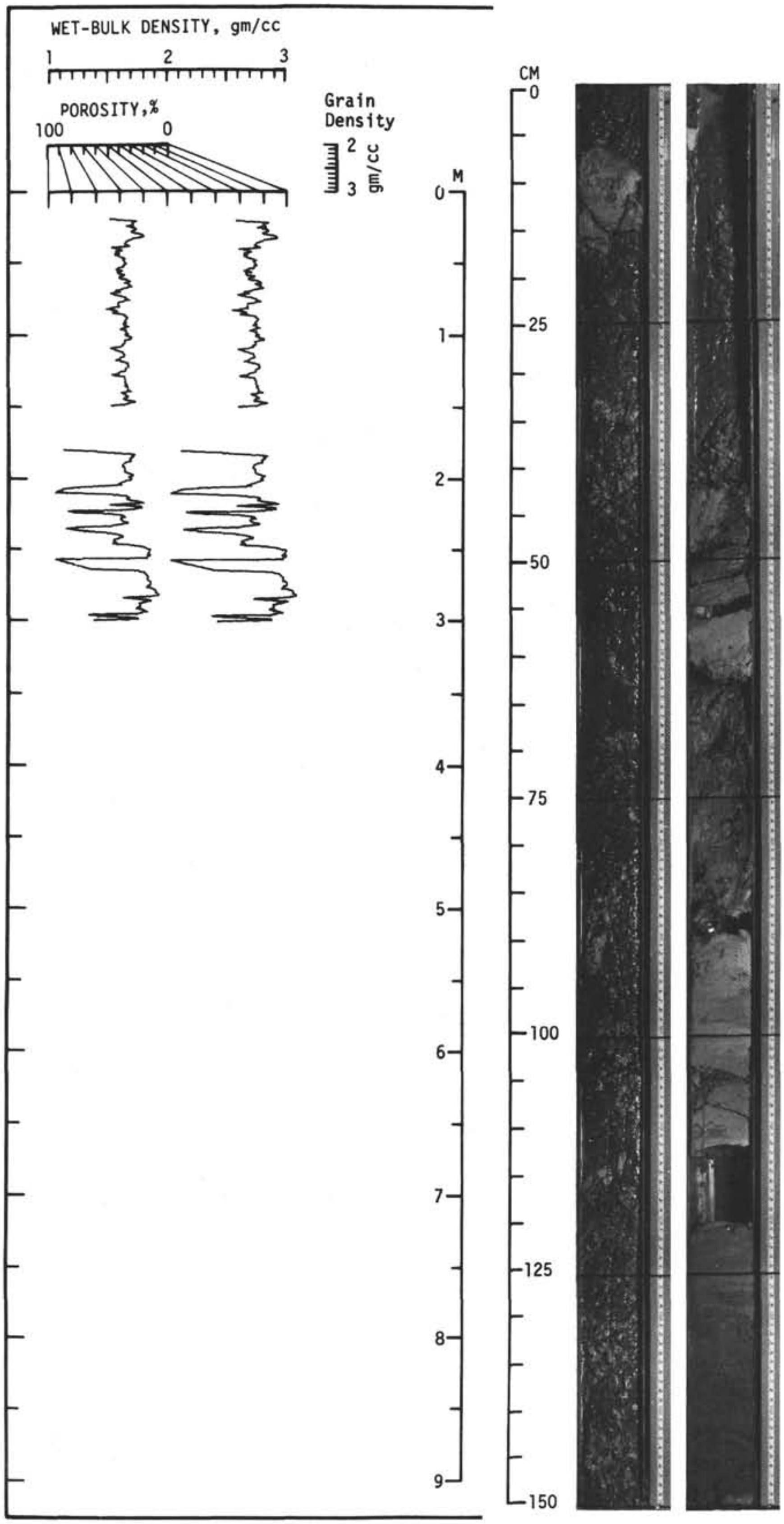
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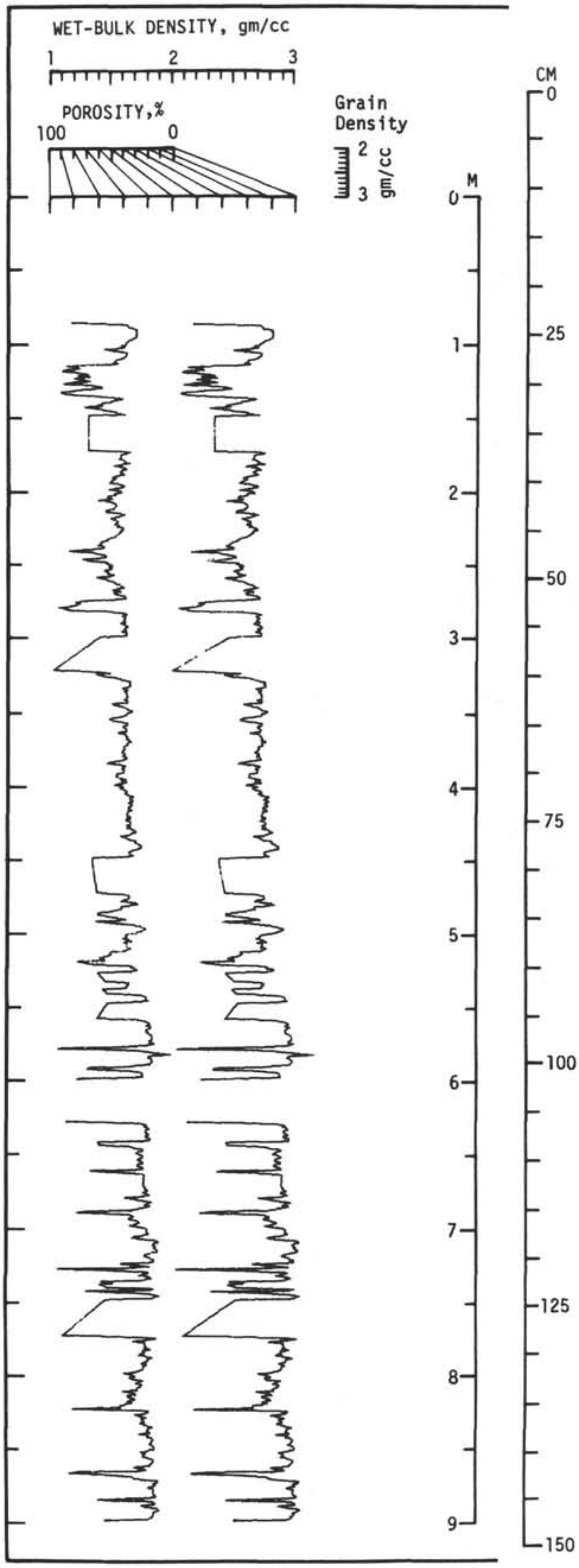

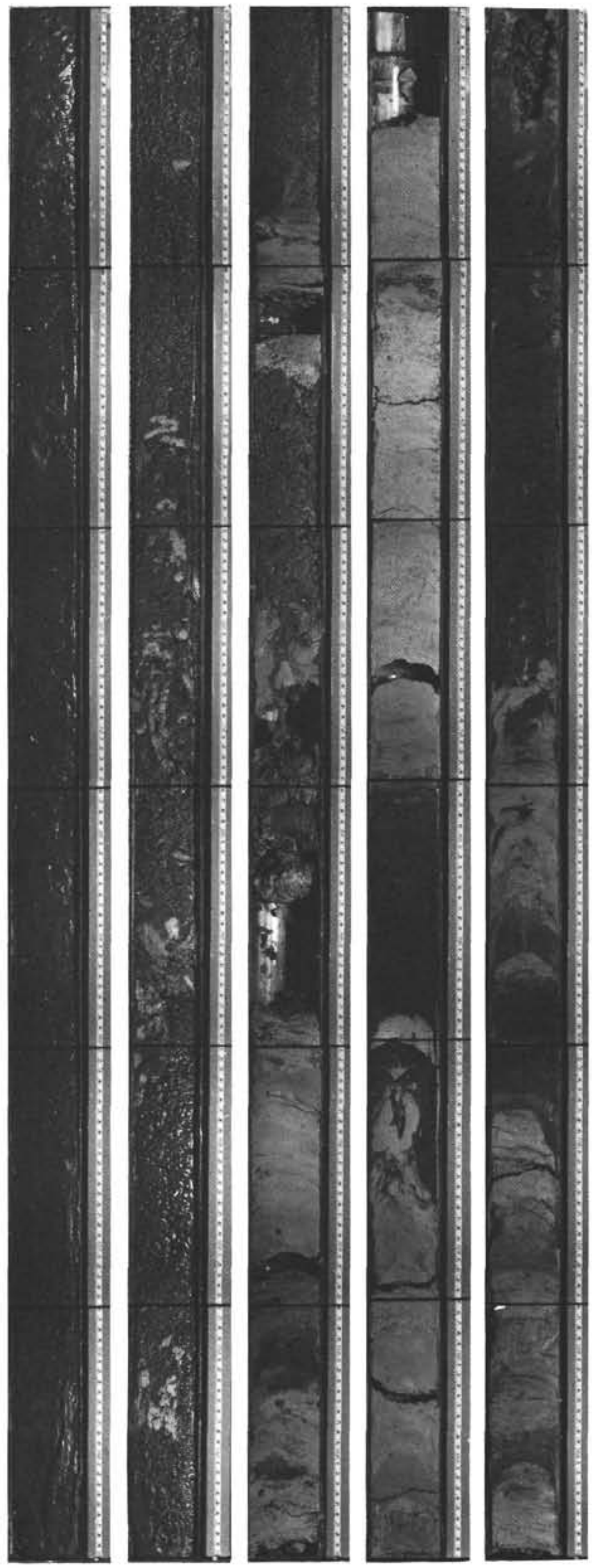

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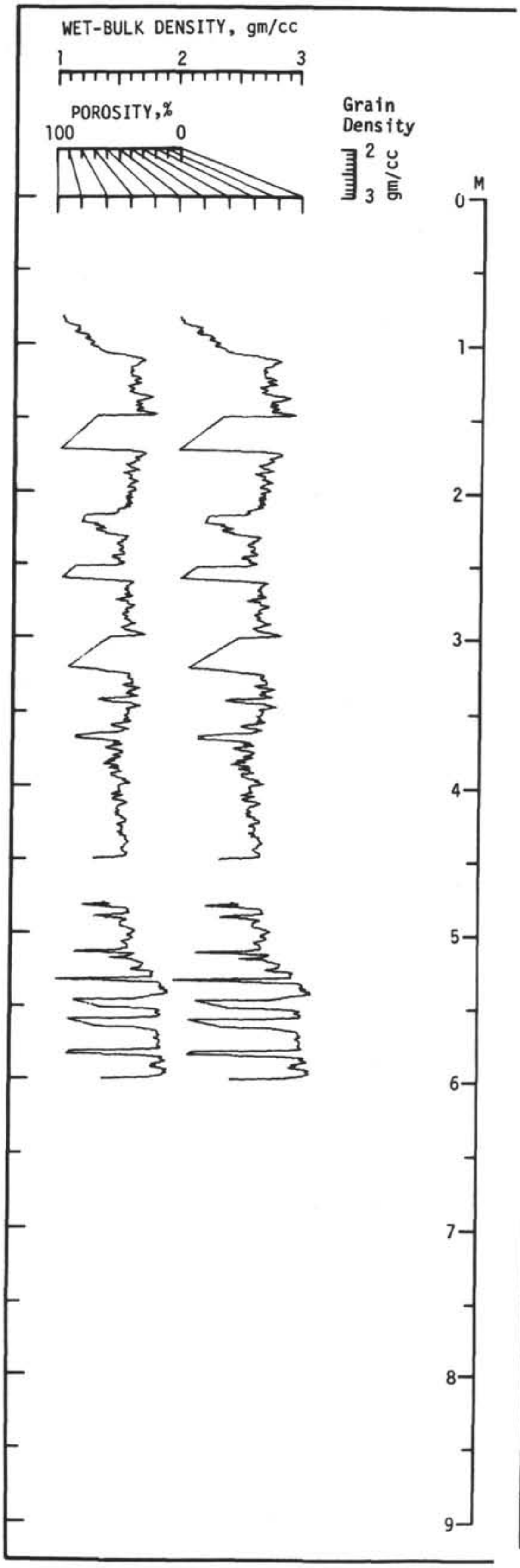

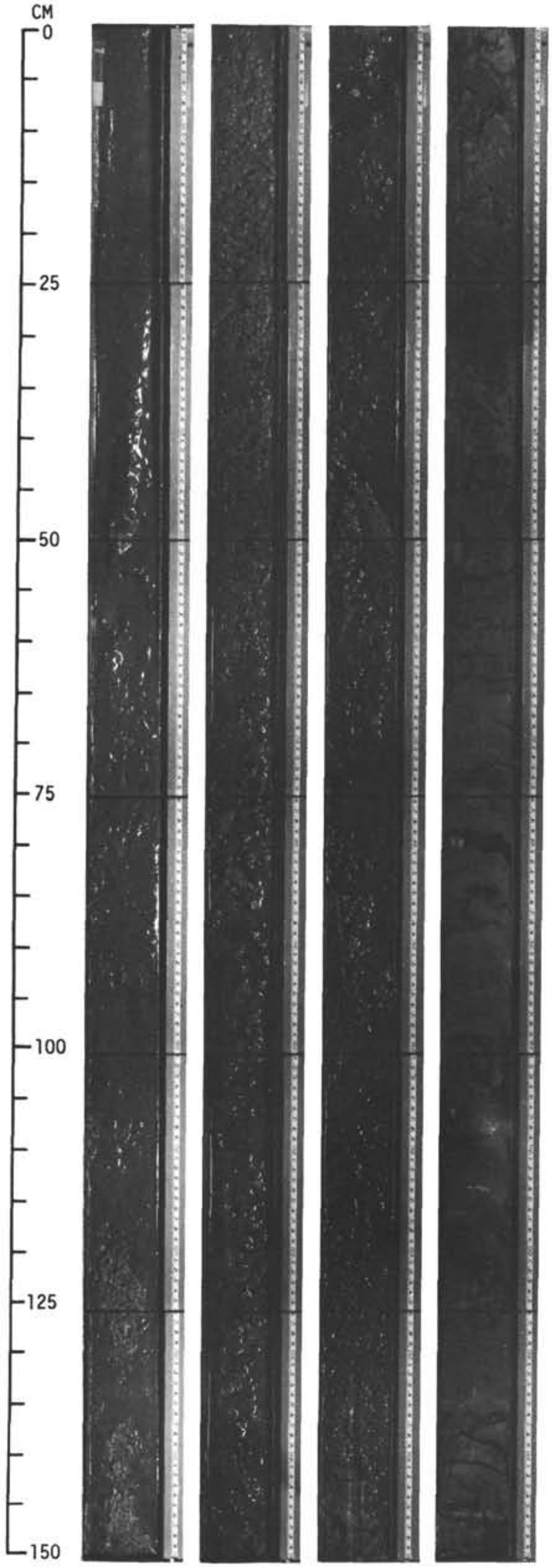

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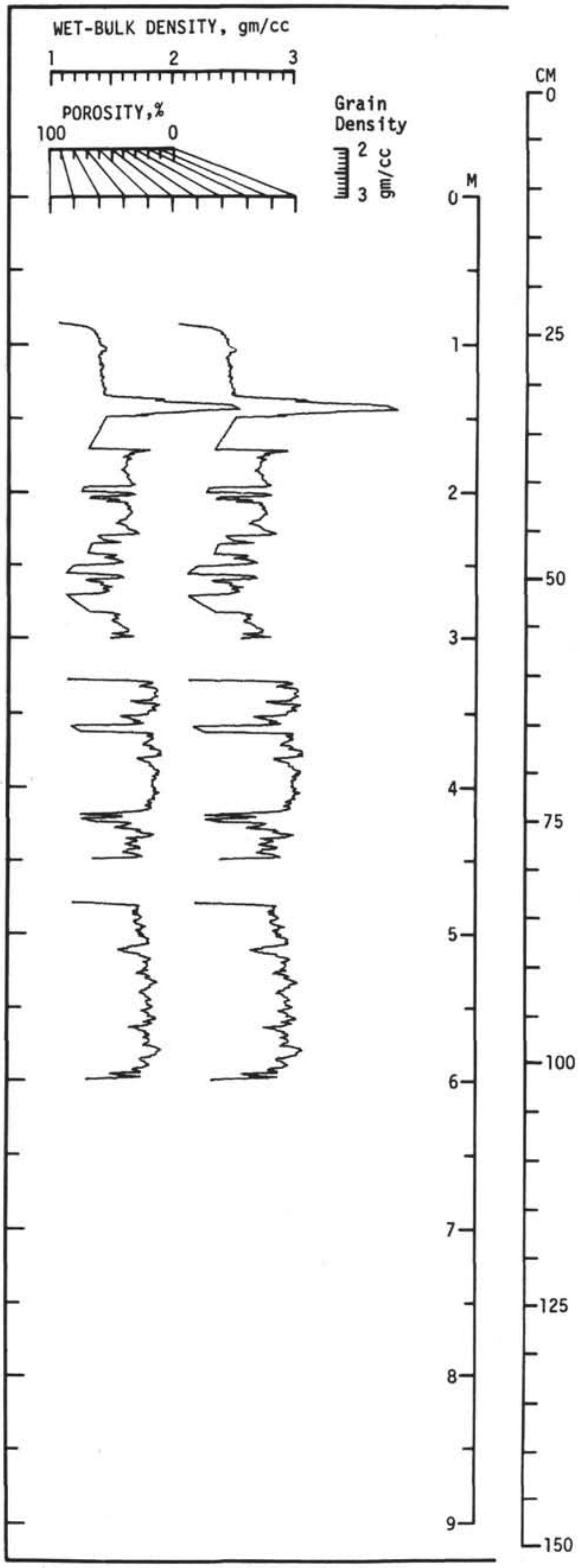

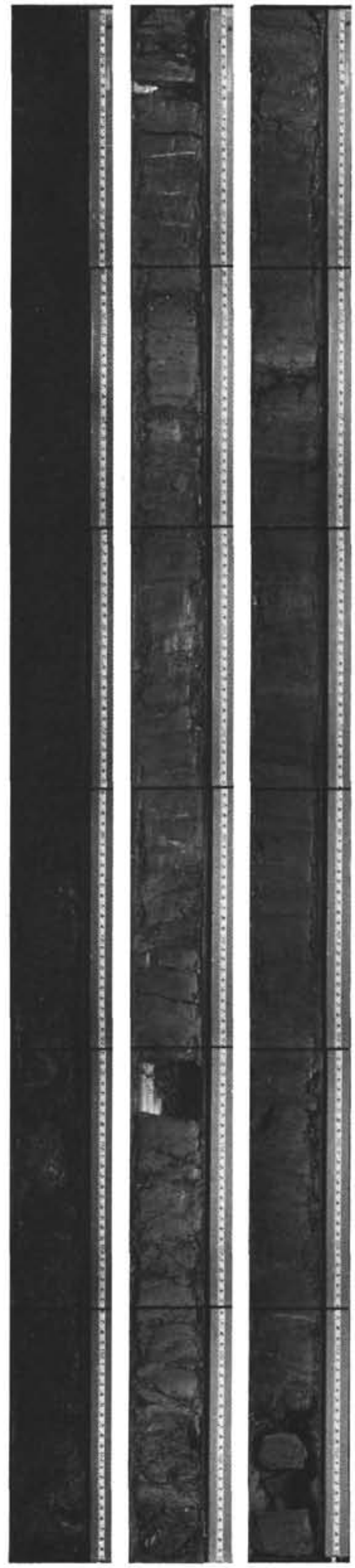

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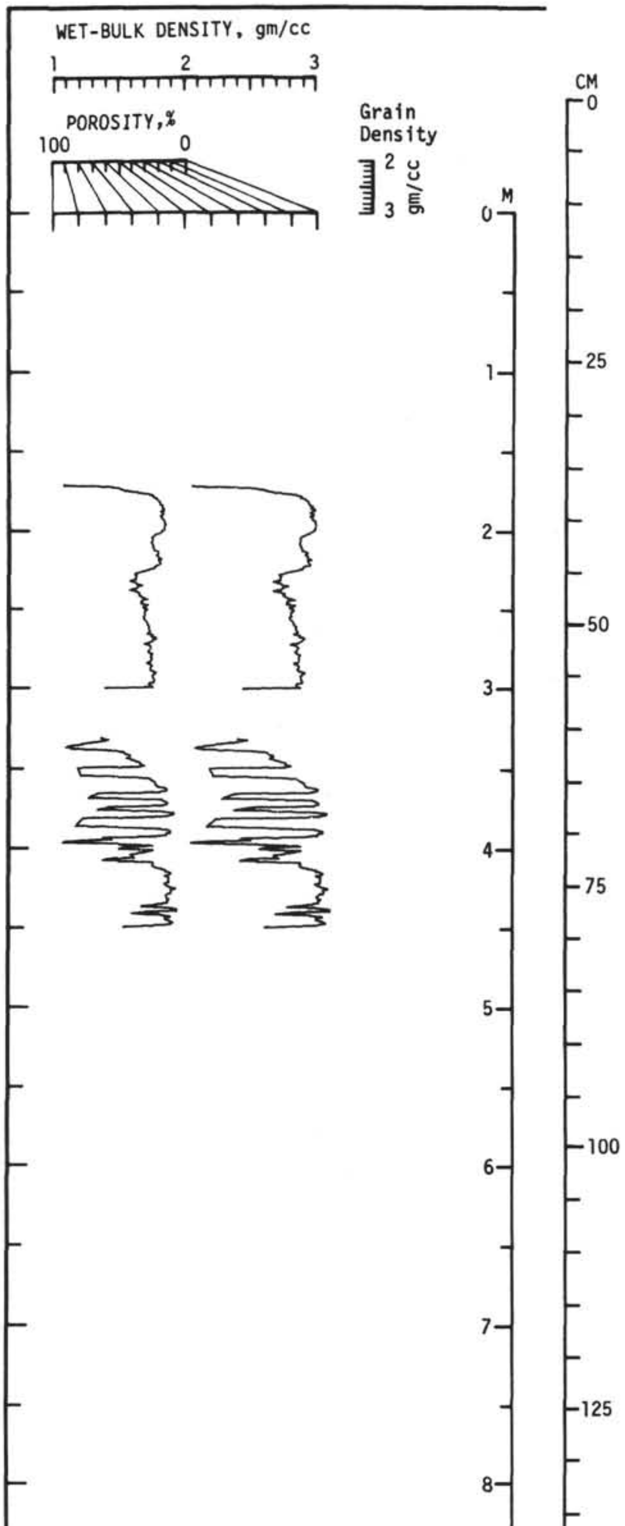
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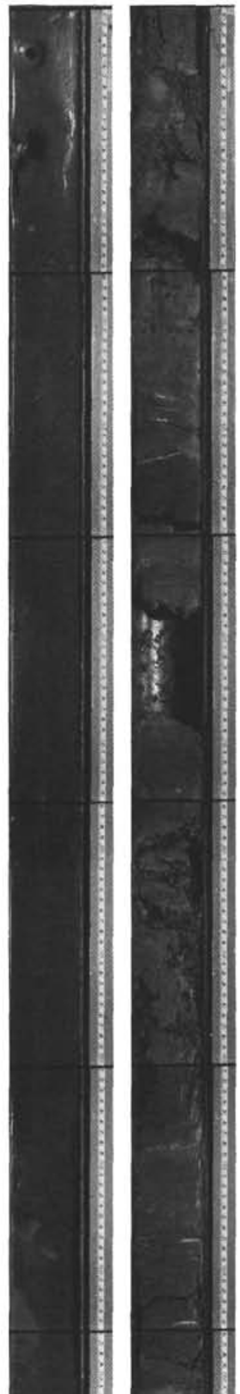

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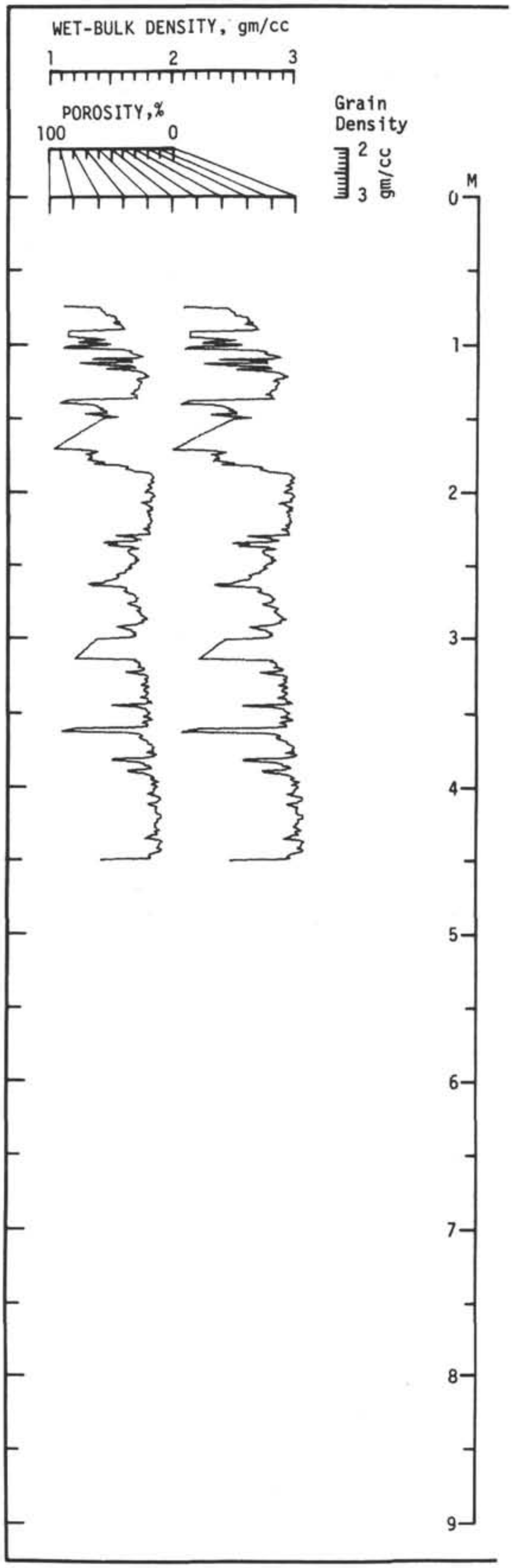

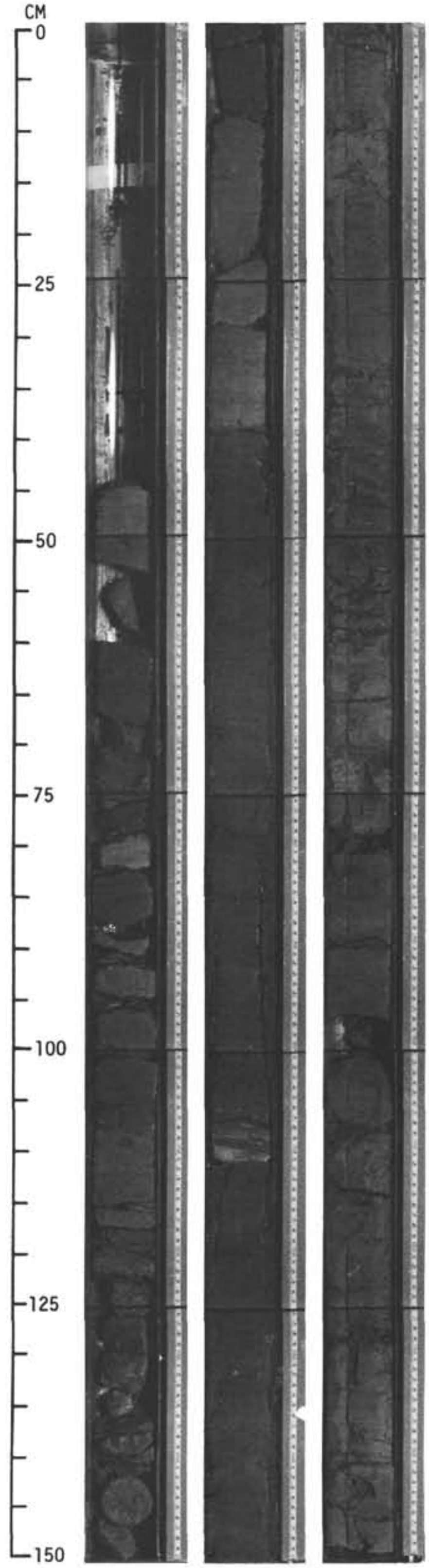

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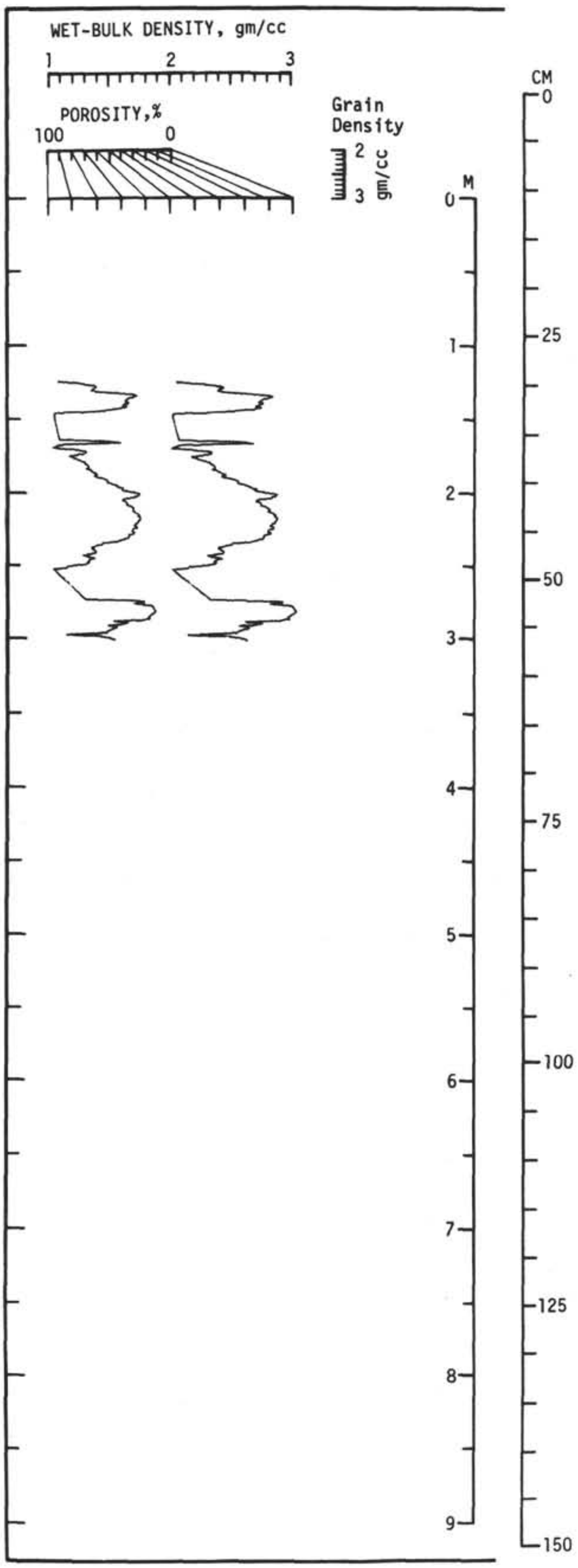
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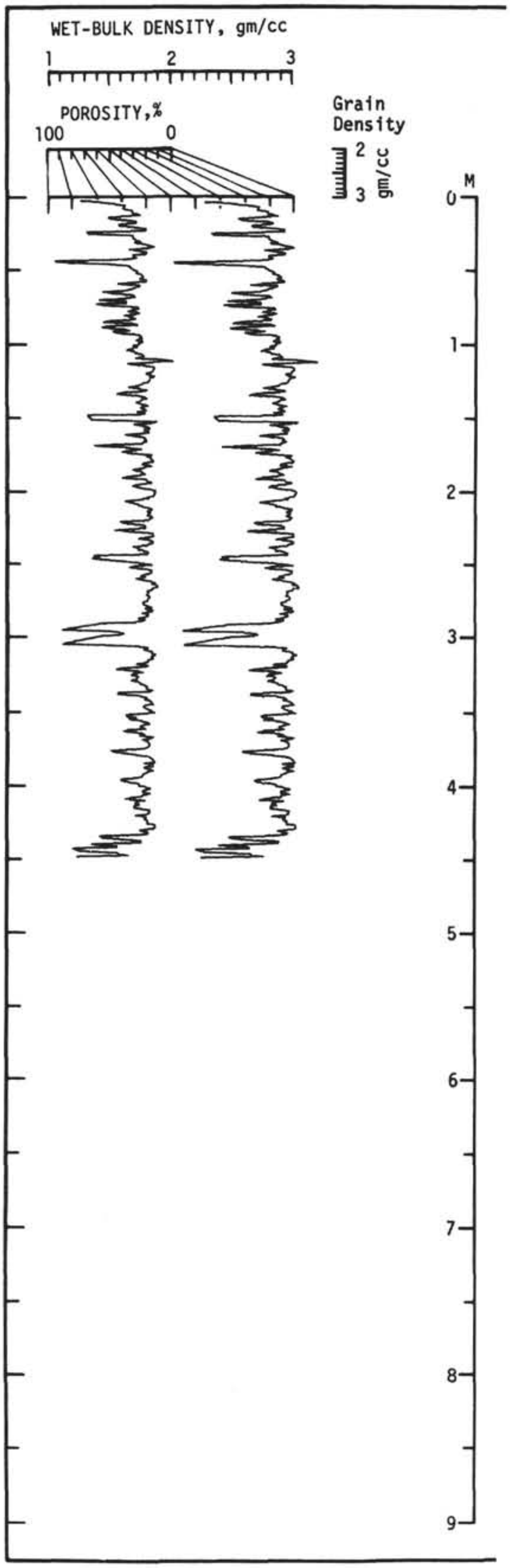

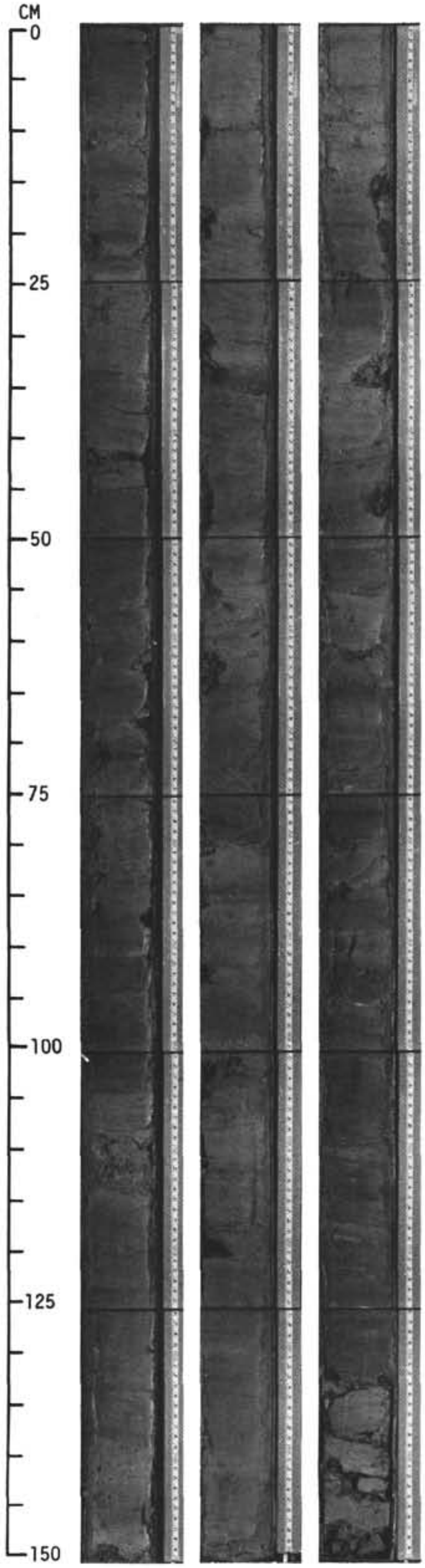

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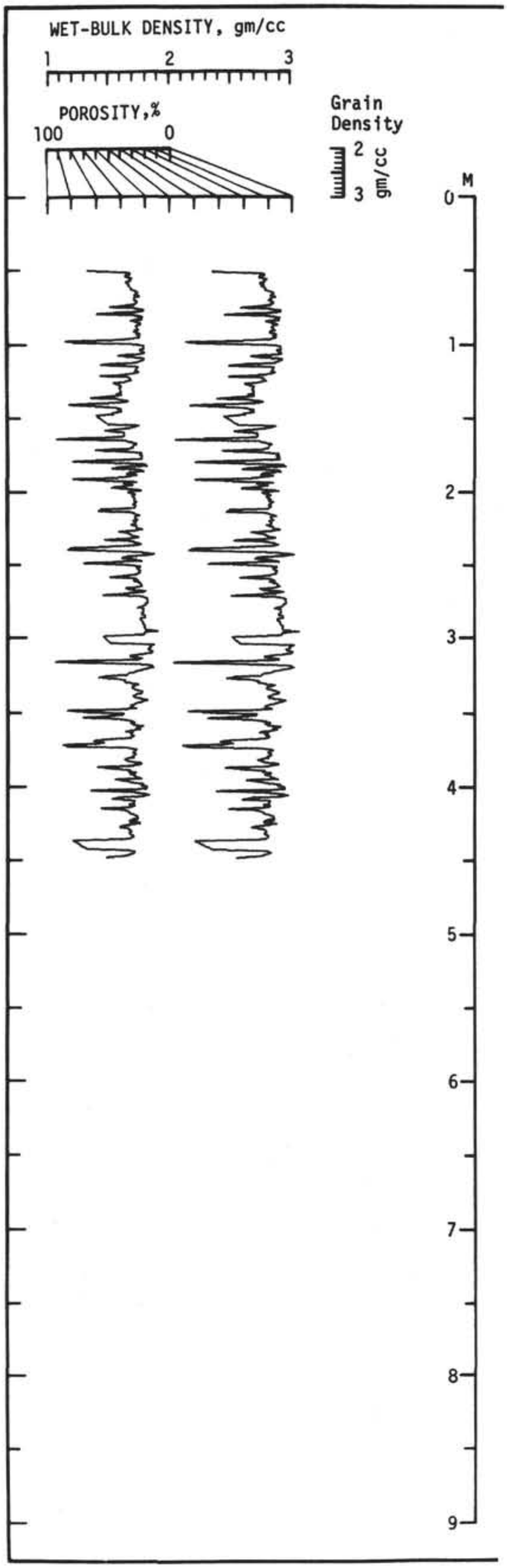

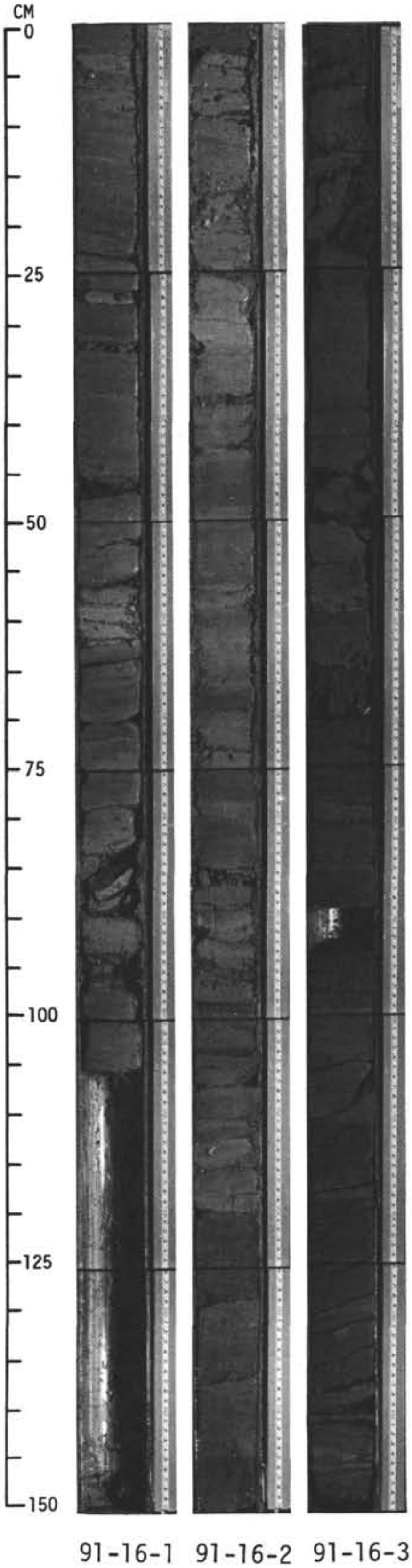

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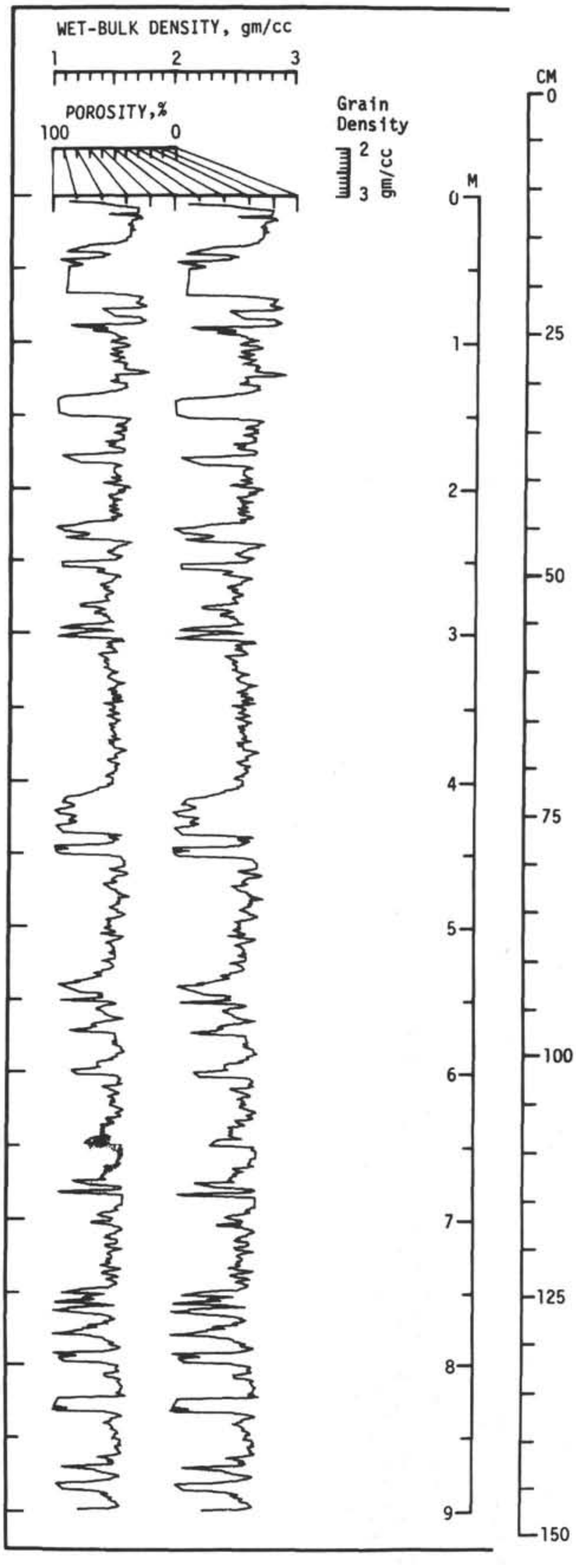

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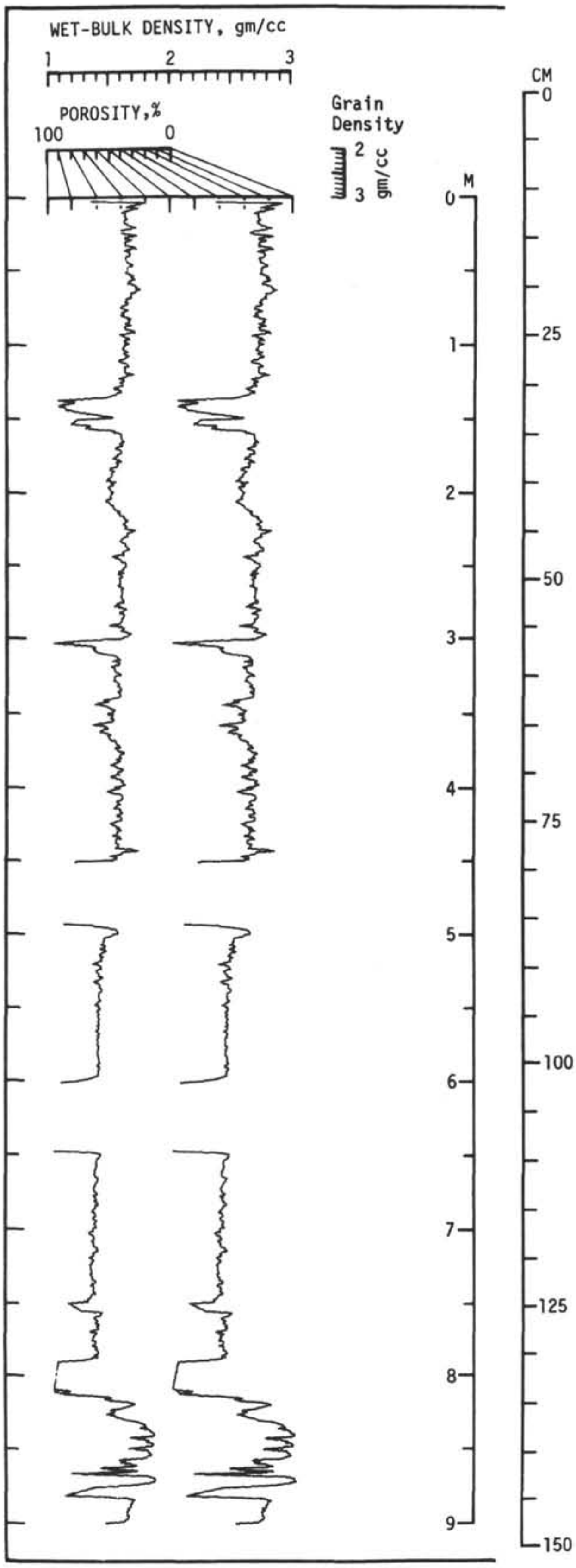
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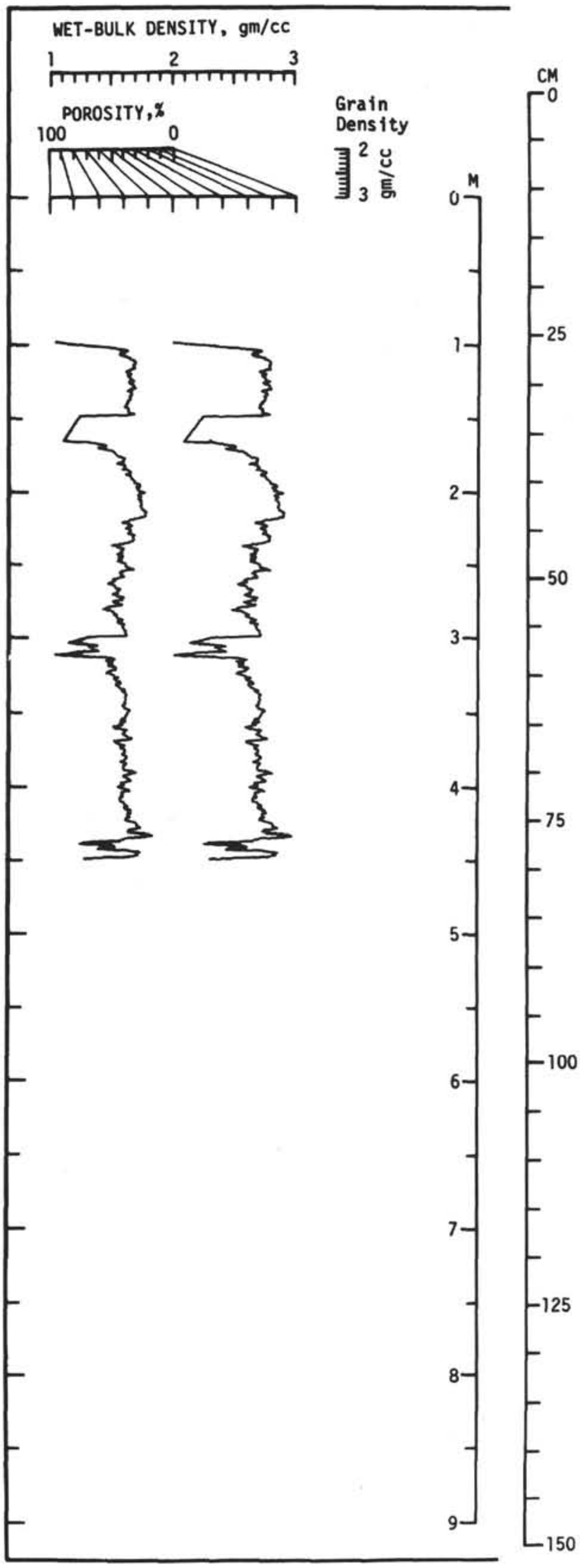

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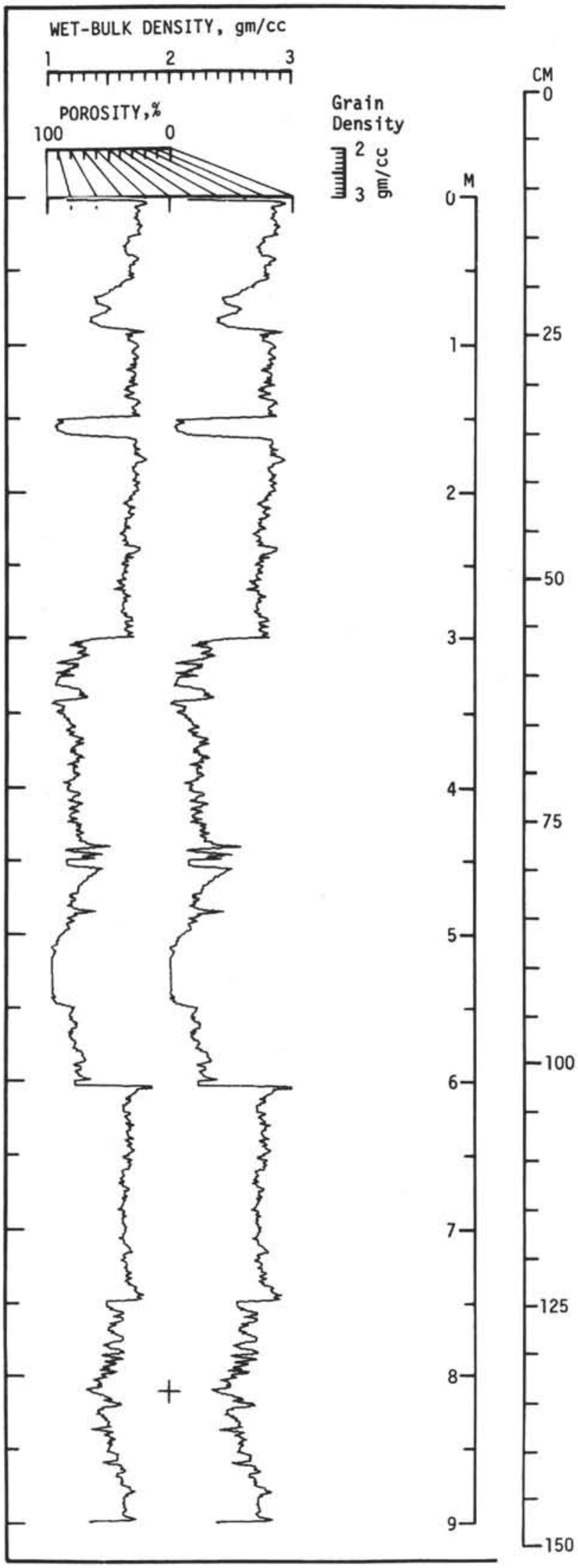
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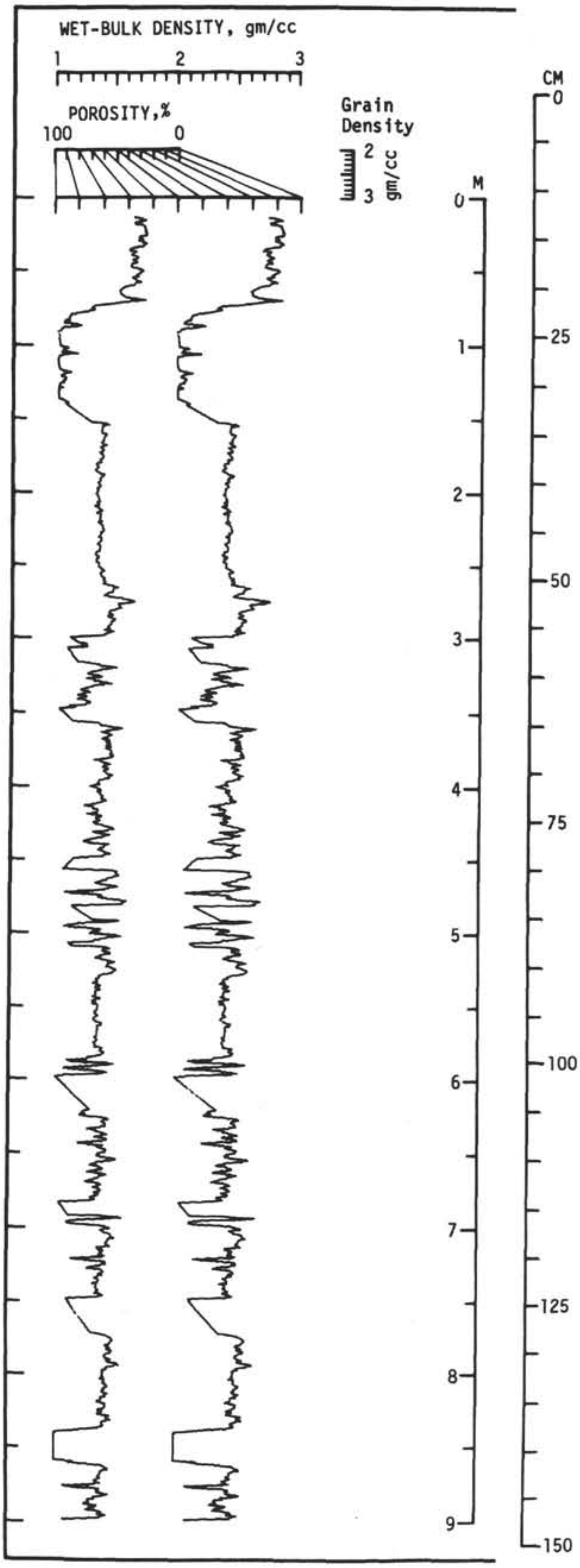
91-20-6



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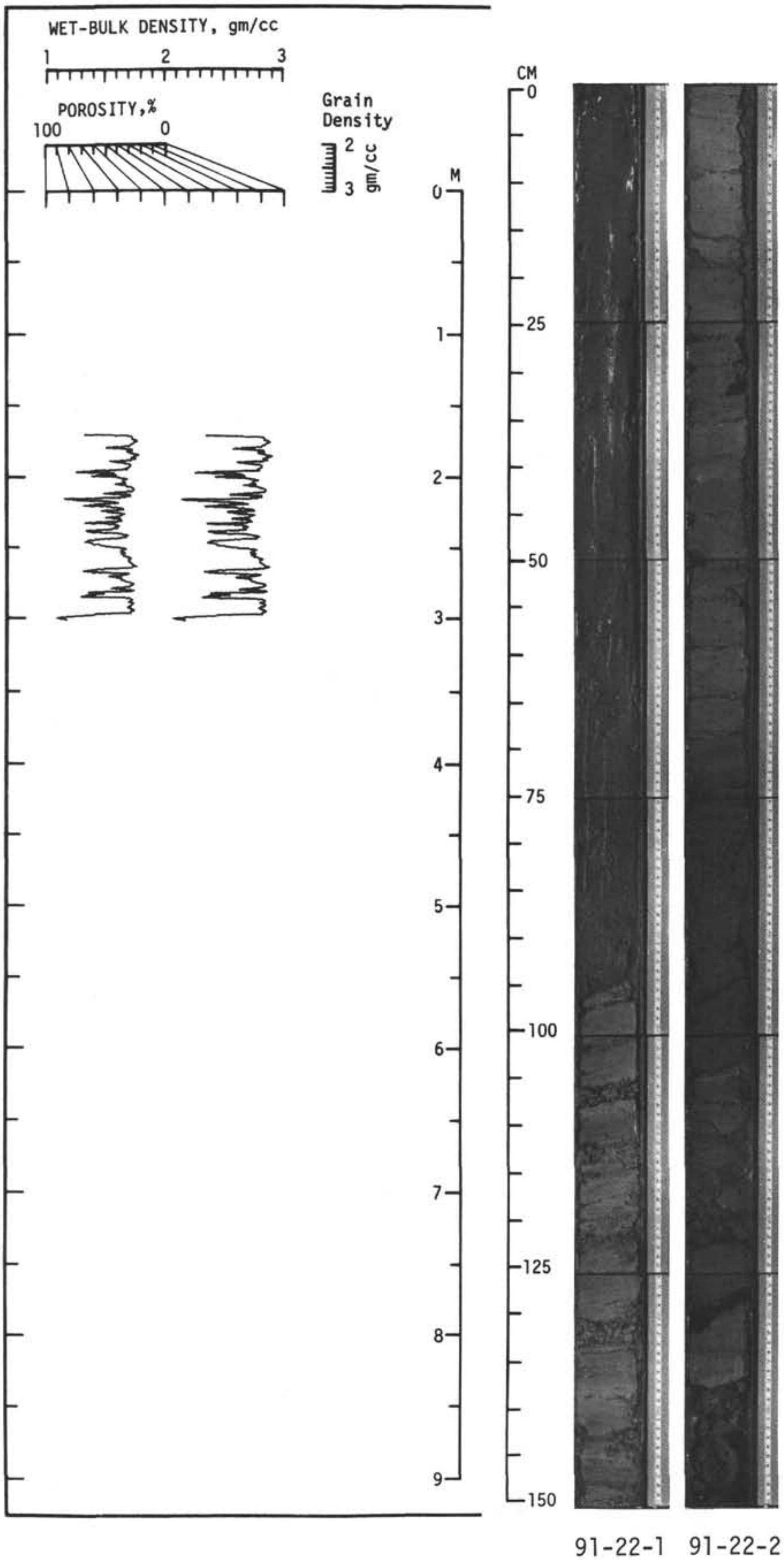
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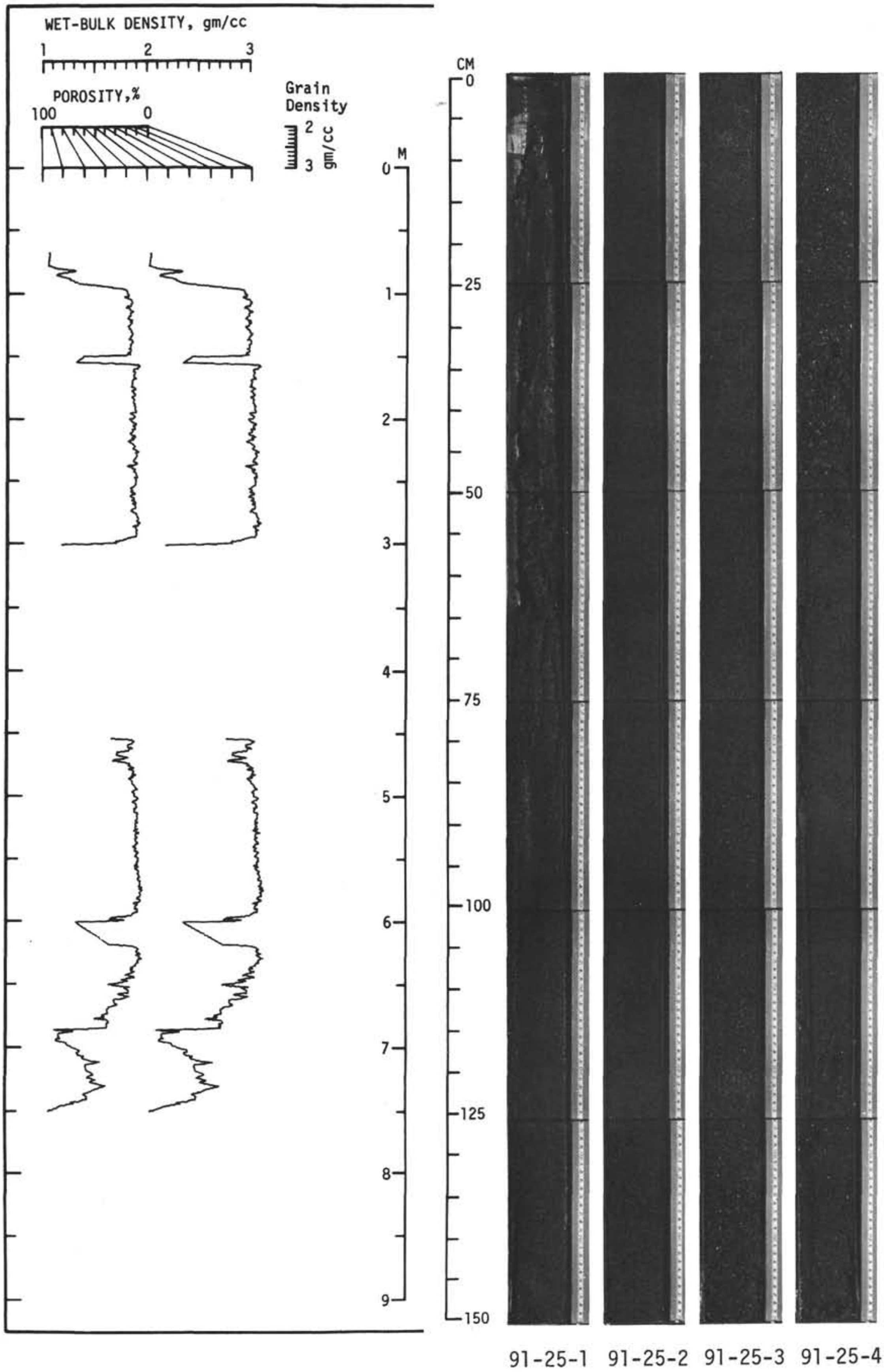
WET-BULK DENSITY, gm/cc
1
2
3
POROSITY,%
100
0
Grain Density
2
3
gm/cc
M
0
1
2
3
4
5
6
7
8
9
CM
0
25
50
75
100
125
150
91-25-1
91-25-2
91-25-3
91-25-4