2. SITE 211

The Shipboard Scientific Party[1]

ABSTRACT

At Site 211, early Campanian and Maastrichtian nannofossil ooze, clay, and ash overlay a weathered and altered amphibole-bearing basalt basement at a sediment depth of 435 meters. The next younger unit is a ferruginous brown clay, intruded near its base by a 10-meter-thick diabase sill. A 200-meter-thick unit of interbedded sands and siliceous oozes overlies the brown clay. The sands are turbidites of Pliocene age and form part of the Nicobar Fan. The uppermost 100 meters of the hole yielded pelagic siliceous oozes and ash beds of late Pliocene and Quaternary age. The ash beds probably originated from island arc volcanism to the north.

SITE DATA

Date Occupied: 21 Jan 72 (0830)

Date Departed: 24 Jan 72 (1030)

Time on Site: 74 hours

Position:
lat 09°46.53′S
long 102°41.95′E

Water Depth (to rig floor):
5528 meters (echo sounding)
5535 meters (drill pipe)

Penetration: 447 meters

Number of Holes: 1

Number of Cores: 15

Total Length of Cored Section: 142.5 meters

Total Core Recovered: 67.21 meters

Acoustic Basement:
Depth: 5970 meters
Nature: Basalt

Age of Oldest Sediment: Early Campanian

Basement: Basalt

BACKGROUND AND OBJECTIVES

The initial drilling plan for Leg 22 in the Indian Ocean called for four sites in the Wharton Basin. The first two sites were close to each other at 9°34.9′S, 102°01.4′E and 7°20.0′S, 100°14.8′E and were picked to determine basement age on the gentle swell seaward of the Java Trench and to examine the differences between two apparently different seismic reflection records. After the presite surveys by R/V *Robert Conrad*, it was discovered that these differences in the records were very local and that both sites showed the same general sediment character. We decided to drill the first site and to consider the second as an alternate should we have problems. Site 211 was located on a flat topographic region on a gentle rise just to the south of the Java Trench and has a depth of close to 5500 meters (Figure 1). The area of the site is bounded to the north by the trench, to the west by the Nicobar Fan—an extension of the Bengal Fan east of the Ninetyeast Ridge—to the south by Cocos Keeling Plateau, and to the east by Christmas Island.

The seismic reflection records in the area are characterized by a transparent layer about 0.1 to 0.3 sec thick on top of a more opaque and diffuse layer of some 0.2 sec. Throughout the area a topographically rough basement can be observed at 0.4 sec depth. However, in isolated regions the basement crops out at the surface. The seismic reflection record from the *Challenger* at the site is fairly typical of the region, and the prominent features of this record can easily be recognized on the form contours from the *Conrad 14* presite survey (Figure 2). The seismic reflection records (this chapter and Chapter 10) show that Site 211 was selected in a small basin with three prominent subsurface reflectors. The bottom reflector was assumed to be basement at a depth of 0.45 sec.

The objectives of this site were to date the basement age and to identify the prominent reflectors on the seismic record.

OPERATIONS

Site 211 was approached along a course of 270° in order to verify a seismic line from the presite survey of the R/V *Robert Conrad*. The site was selected in a sediment basin approximately 12 nautical miles in length, containing about 0.4 to 0.5 sec of sediment overlying basement. The site chosen is about 15 nautical miles east of the

[1]C. C. von der Borch, Flinders University, Bedford Park, South Australia; J. G. Sclater, Scripps Institution of Oceanography, La Jolla, California; S. Gartner, Jr., Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, Florida; R. Hekinian, Centre Oceanologique de Bretagne, Brest, France; D. A. Johnson, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; B. McGowran, University of Adelaide, Adelaide, South Australia; A. C. Pimm, Scripps Institution of Oceanography; La Jolla, California; R. W. Thompson, Humboldt State College, Arcata, California; J. J. Veevers, Macquarie University, North Ryde, N.S.W., Australia; Lee S. Waterman, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

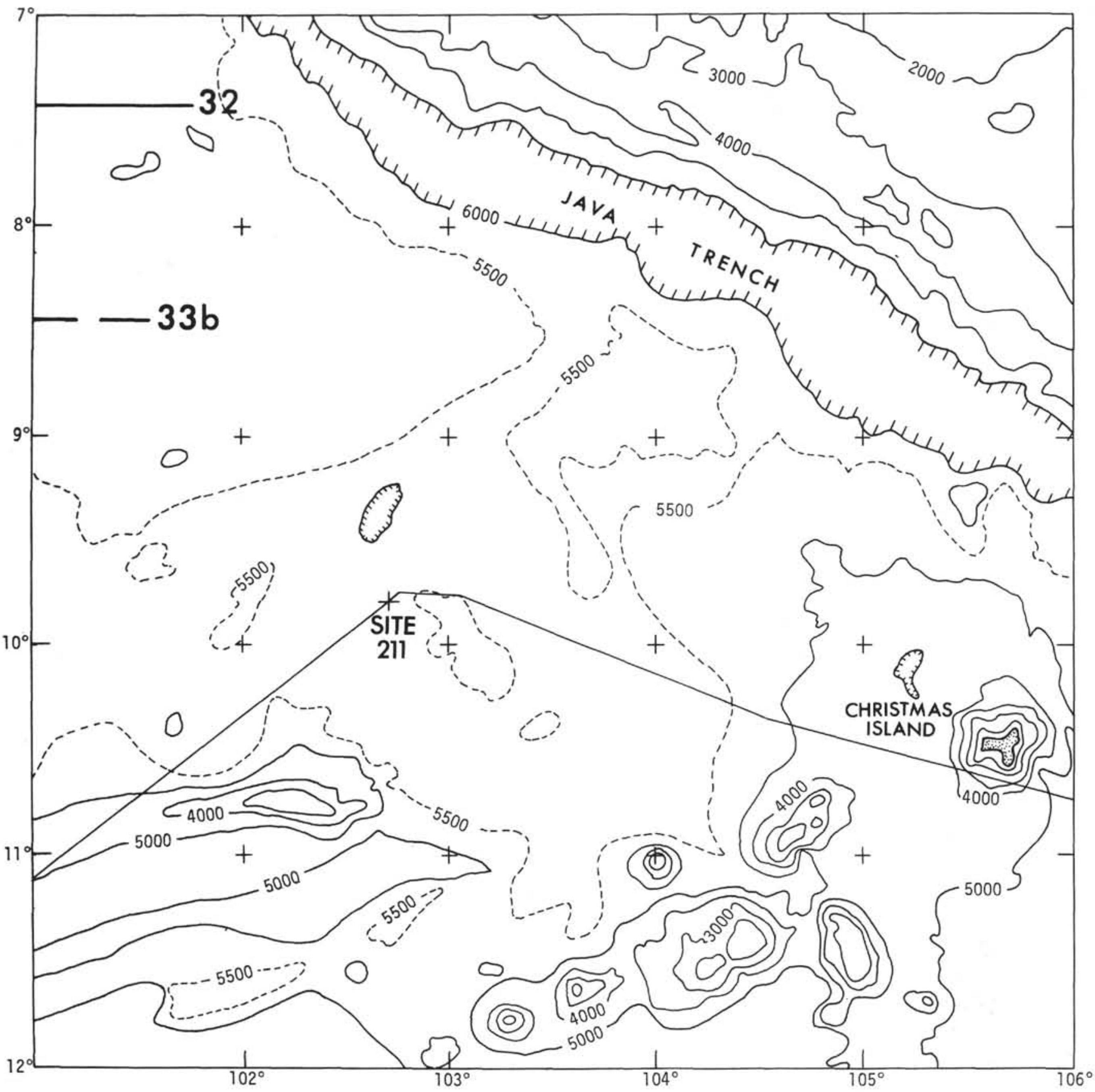


Figure 1. *Bathymetry and magnetic anomalies in vicinity of Site 211.*

recommended site, the choice being governed by the presence of less intense seismic reflectors in the new site compared with the original selection. A spar buoy was dropped over the proposed drilling location, after which the seismic gear was secured and the vessel reversed course to the buoy.

Coring was planned on the basis of one barrel every 30 or 40 meters of drilling, with continuous coring in the basalt section. A 4-cone chizzel-point bit was used, and a total of 15 cores was ultimately recovered (Table 1).

The unconsolidated siliceous pelagic ooze of the uppermost 100 meters was sampled by employing controlled pump pressure to avoid washing. The underlying turbidite sand sequence was successfully cored, although it provided some anxious moments due to sand flowage. Fortunately, deeper sands contained sufficient clay to stabilize the hole. Difficult drilling conditions were obtained in stiff brown clay section below the turbidite due to bit clogging. A 10-meter-thick sill was cored without difficulty near the bottom of the hole, followed by stiff calcareous clay and finally basaltic basement. The stiff calcareous clay again caused problems by clogging the bit. However, the basalt basement was cored without difficulty to a thickness of 12 meters, with 60% recovery.

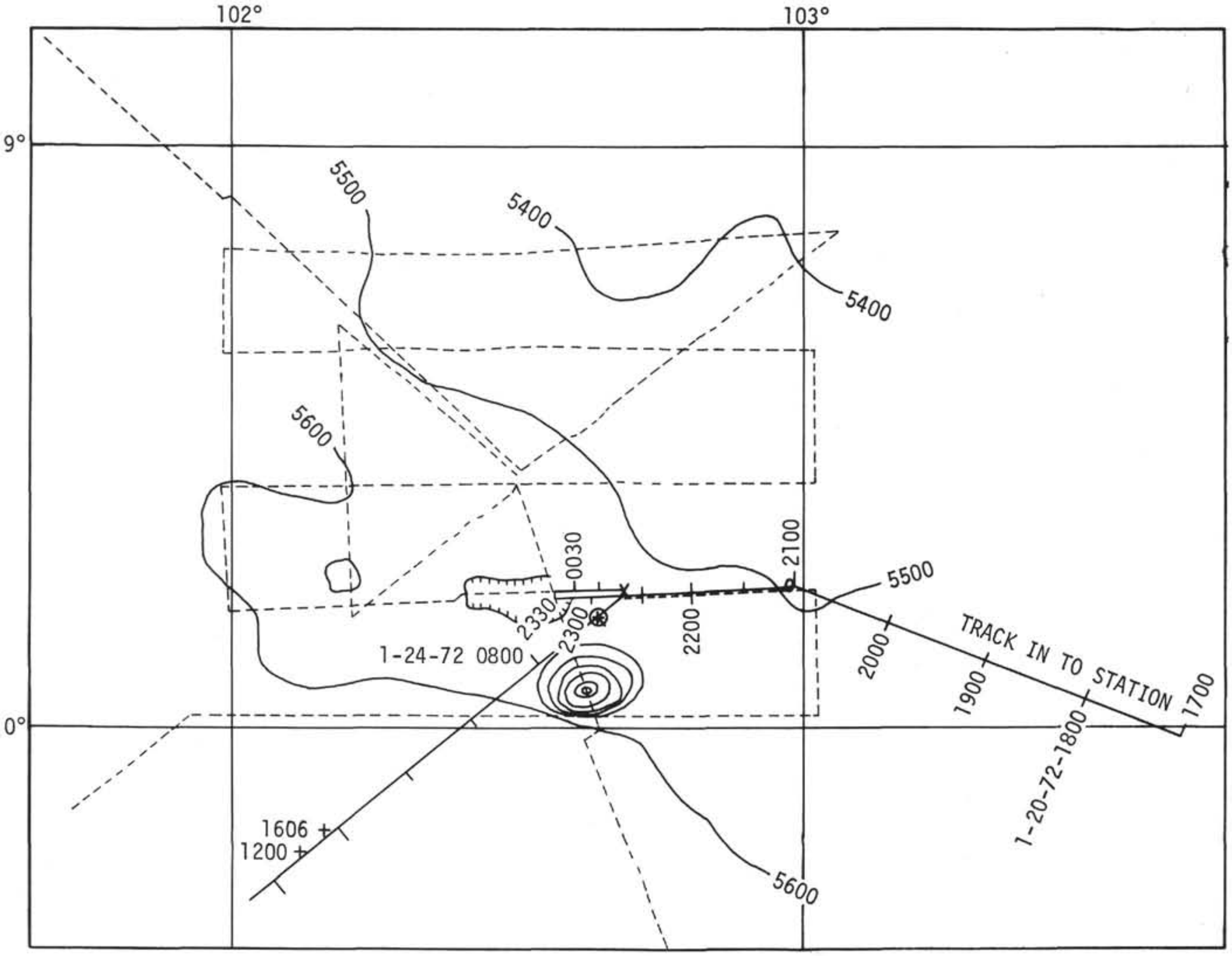


Figure 2. *Presite survey and form lines for Site 211.*

LITHOLOGIC SUMMARY

Introduction

At Site 211 Quaternary to lower Campanian sediments were penetrated to a depth of 428 meters, below which weathered basalt was recovered. Coring was attempted for 143 meters from which 54 meters of sediment and 13 meters of igneous material were obtained (Figure 3). The following lithologic units can be recognized.

Unit	Depth Below Sea Floor (m)	Lithology	Age	Cores
1	0 to 95	Clay-rich siliceous ooze with volcanic ash beds	Quaternary to upper Pliocene	1-3
2	95 to ~200	Rad-rich clay or clay-rich rad ooze with abundant silt/sand at top decreasing downward	Pliocene	4-6
3	~200 to ~335	Clayey silt/silty sand decreasing in grain size downwards to silty clay	Pliocene to Miocene (?)	7-9
4	~335 to ~401.5	Brown clay passing down into amorphous iron oxide and pyrite-rich ash facies	?	10-11
5	401.5 to 411.5	Diabase sill	?	12
6	411.5 to 428.5	Variegated gray, cream, and red nanno ooze and clay	Basal Maastrichtian to Basal Campanian	12-14
7	428.5 to 447	Weathered amphibole-bearing basalt and amphibolite	?	14-15

Description

Unit 1—Clay-rich Siliceous Ooze with Volcanic Ash Beds (Cores 1-3)

This unit is mostly siliceous ooze with a small admixture and a few thin (⩾15 mm) interbeds of volcanic ash. The major components of the siliceous ooze are diatoms, but Radiolaria, sponge spicules, and, to a lesser extent,

TABLE 1
Coring Summary, Site 211

Core	Date (Jan)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Length Cored (m)	Recovered (m)	Recovery (%)
1	22	0025	5535.0-5544.0	0-9.0	9.5	9.0	100
2	22	0230	5544.0-5553.0	9.0-18.0	9.5	9.0	100
3	22	0450	5592.0-5601.5	57.0-66.0	9.5	7.5	83
4	22	0720	5630.0-5639.5	95.0-104.5	9.5	3.8	43
5	22	0935	5668.0-5677.5	133.0-142.5	9.5	7.9	83
6	22	1220	5715.5-5725.0	180.5-190.5	9.5	9.5	100
7	22	1520	5763.0-5772.5	228.0-237.5	9.5	1.5	20
8	22	1800	5791.5-5801.0	256.5-266.0	9.5	1.1	14
9	22	2110	5829.5-5839.0	294.5-304.0	9.5	3.7	40
10	23	0015	5877.0-5886.0	342.0-351.0	9.5	0.6	6
11	23	0315	5924.5-5933.0	389.5-398.0	9.5	(CC)	0
12	23	1120	5944 0-5953.5	409.0-418.5	9.5	3.1	35
13	23	1410	5953.5-5963.0	418.5-428.0	9.5	1.3	15
14	23	1635	5963.0-5972.5	428.0-437.5	9.5	3.4	37
15	23	2220	5972 5-5982.0	437.5-447.0	9.5	5.7	62
Total					142.5	67.1	47.2

Note: Echo sounding depth (to drill floor) = 5528 meters;
drill pipe length to bottom = 5535 meters.

silicoflagellates are also common. Clay minerals of terrigenous and volcanic origin are abundant in the ooze, and in places the sediment becomes a radiolarian-rich clay. Glass shards, feldspar, and pumice fragments make up less than 10% of the siliceous oozes. The volcanic ash is mostly (50%-90%) made up of fresh clear rhyolitic glass shards of silt and fine sand size, the remainder of the components being clay minerals, quartz, feldspar, and heavy minerals.

Unit 2–Radiolarian-rich Clay or Clay-rich Radiolarian Ooze with Silt and Sand (Cores 4-6)

In this unit clay with siliceous fossils, similar to Unit 1 except that Radiolaria are more abundant than diatoms, is interbedded with terrigenous silt and sand. In the lower part of the unit (Core 5, 6) the clay is predominantly of volcanic origin (see X-ray data).

The terrigenous material is highly feldspathic (up to 60%), the feldspathic component seen in smear slides consisting almost completely of orthoclase with minor microcline and sodic plagioclase (this is in direct contrast to the X-ray data). Biotite and muscovite are present in amounts of 15% to 30%, while smaller amounts of clay and minor quartz and heavy minerals make up the remainder.

Unit 3–Clayey Silt/Silty Sand to Silty Clay (Cores 7-9)

This is similar to the terrigenous component in Unit 2 and makes up all of this unit, the major variation being the presence of finer-grained, silty clay beds interbedded with the silty sands lower down. Heavy minerals have been tentatively identified as belonging to the hornblende-epidote suite. Mica appears to be less common here than in the terrigenous component on Unit 2.

In Core 7 a few rounded fragments of indurated calcareous siltstone were seen and are presumably reworked from elsewhere.

Unit 4 –Brown Clay, Amorphous Iron Oxide, and Pyrite-rich Ash Facies (Cores 10-11)

Two cores in this unit show a transition from iron-oxide-rich brown clay to an amorphous iron-oxide facies with three distinct sediment types: (1) moderate brown homogeneous amorphous iron-oxide (with a consistency of firm clay) comprising 70% iron-oxide minerals, 20% clay minerals, and 10% remanats of glass shards, feldspar, and heavy minerals; (2) moderately indurated dark gray, pyrite-rich ash which is dominantly (80%) devitrified basaltic glass shards almost totally replaced by iron-oxide. Pyrite and less common minute grains of iron-oxide minerals make up the rest of the sediment; (3) moderately indurated red ash-rich iron oxide. This sediment is about 90% iron aggregates, many of which are hematitic with 10% remnant altered glass shards similar to (2) above. Traces of feldspar and cristobalite (?) aggregates were seen.

Unit 5–Diabase Sill (Core 12)

Unit 5 is a 10-meter-thick igneous intrusive phaneritic rock with a diabasic texture. While most of the anhedral and subhedral plates of clinopyroxenes are partially enclosed by plagioclase laths, only few larger pyroxenes show poikilitic inclusions of plagioclases. The plagioclase (2 to 3 mm in length) comprise about 40% of the bulk rock. Clinopyroxene is the next most abundant (<25%) mineral. Phyllosilicates (21%) comprising serpentine and mixed layer of vermiculite-chlorite occur. The minor constituents

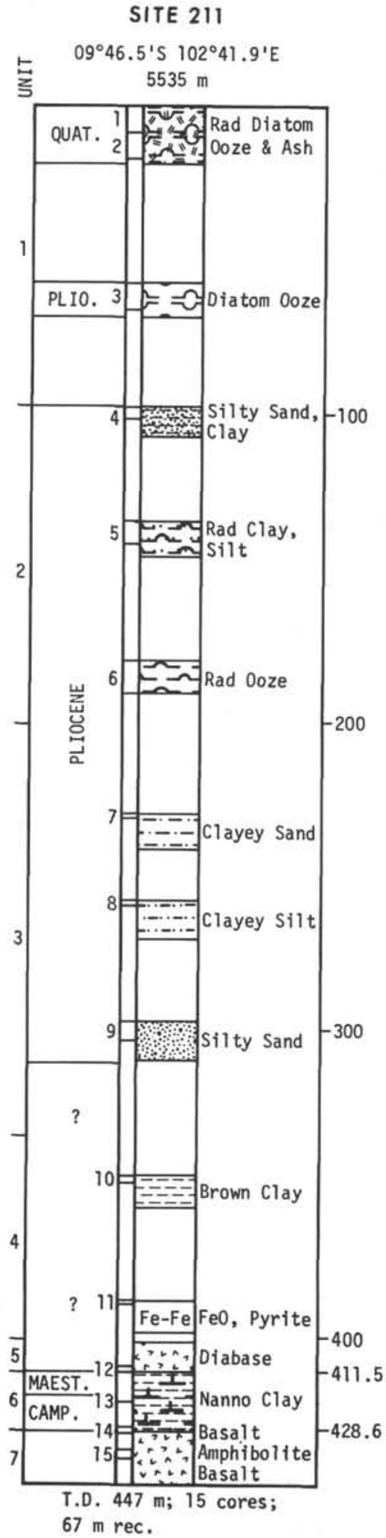


Figure 3. *Lithologic units at Site 211.*

consist of iron ore (5%) often surrounded by flakes of biotite (7%) and needles of amphibole (<3%). Calcite, zeolite, and pyrite occur as accessory minerals throughout the unit. Calcite and aggregates of siliceous material occur as inclusions in the most sodic plagioclase laths.

The upper contact was not cored. The lower contact of the sill was recovered and comprises about 20 cm of hypocrystalline fine-grain rock with an intersertal texture. The interstices of the plagioclase laths are filled with palagonite, calcite, iron oxide, and granules of clinopyroxene. This lower part of the sill probably represents a chilled margin.

Unit 6—Variegated Nannofossil Ooze, Nannofossil Clay, and Iron-rich Ash (Cores 12-14)

This unit comprises rapid alternations of red, cream, and gray nannofossil-rich clay, nannofossil clay, and nannofossil ooze. In addition to nannofossils and clay minerals, feldspar, zeolite (?), dolomite, and heavy minerals also occur.

Immediately beneath the "andesitic" diabase sill the sediment is a dusky red, but this red color which is due to iron minerals, fades out quickly so that 20 cm below the contact the color is only light brown to gray orange. A few, rare, iron-rich ash beds also occur and consist of strongly altered volcanic glass, mostly replaced by iron-oxide minerals with incipient plagioclase and palagonite, and common heavy minerals (goethite or limonite and hematite) with feldspar, nannofossils, and mica.

Unit 7—Weathered Amphibole-bearing Basalt (Cores 14, 15)

This unit consists of phaneritic (coarse-grained) and aphanitic (fine-grained) weathered basalt. Often the phaneritic basalt grades towards aphanitic abundantly altered zones. Such a sequence was recognized 12 times within the 8 meters of cored basalt. These alternate sequences of textural changes accompanied by grain-size changes could be attributed either to the presence of several laval pillows or to a series of separate flows.

The phaneritic basalt zone has a hyalopilitic texture where the interstices of the plagioclases are filled with a dark mesostasis. This latter zone also contains abundant amygdales. The aphanitic basalt zone has a variolitic texture in which radiating clusters of feldspar laths are set in a matrix of weathered mesostasis. Little fresh glass was found in the core.

Amphibolite (Core 14, Section 2 and Core 15, Sections 1, 2)

These rocks are intruded within the amphibole-bearing basalt. The amphibolites form several flows (about four) with sharply defined and altered margins. The inner portion of the amphibolites are more crystalline and coarser grained. These amphibolites are made up of about 80% amphiboles, olivine and mica, with 20% calcite and groundmass.

GEOCHEMISTRY PROGRAM

Samples were collected from 11 of the 12 cores which contained more than a kilogram of sediment. The sampling technique and handling procedure is described in Chapter 1. The recovery from Core 7 (1 section) was judged to be unsuitable for sampling because of the large quantity of freely moving water retained in the core liner. Samples from Cores 1 through 6 and Core 9 were obtained and processed immediately upon recovery. Samples from Cores 8, 12, 13, and 14 were taken after the cores had been in the laboratory for a full day or more. A summary of the results is given in Table 2.

In the case of Core 8, the sediment sample was taken from the split core section by the method described in the Interstitial Water Program Instruction Manual, Chapter 1, Section 5. Small "biscuits" of unsplit, indurated sediment were taken from Cores 12, 13, and 14. These sediments had been standing in trays fashioned from split plastic liner since being opened for initial inspection immediately upon recovery. Drying was retarded by using the other half of the split liner as a cover. The sediments were moist to the touch at the time of sampling. Handling was kept to a minimum, and entire portions were squeezed to the maximum limit of the hydraulic press in order to obtain sufficient amounts of fluid for the minimum pore water program.

TABLE 2
Shipboard Chemistry Results

Core, Section, Interval (cm)	pH	Water (%)	Porosity (%)	Density (gm/cc)
1-1, 90	–	77	96	1.25
1-2, 125	–	67	88	1.31
1-3, 0	7.7	71	92	1.28
1-5, 90	–	65	90	1.39
1-6, 4	–	67	89	1.32
2-3, 0	7.4	69	91	1.32
3-1, 85	–	64	86	1.34
3-4, 0	7.4	65	91	1.41
4-2, 20	–	26	49	1.93
4-2, 76	–	63	85	1.35
4-3, 0	7.1	42	68	1.63
5-2, 30	–	63	87	1.38
5-4, 71	–	23	48	2.07
5-5, 0	7.2	45	73	1.63
6-5, 0	7.1	24	50	2.04
6-5, 7	–	25	50	1.95
6-6, 50	–	62	87	1.41
8-1, 89	7.6	–	–	–
8-1, 120	–	16	32	2.06
9-2, 133	–	24	46	1.94
9-3, 0	7.8	15	34	2.24
9-3, 140	–	15	33	2.19
11, CC	–	30	–	–
12, CC	7.3	36	–	–
13-1, 55	7.1	32	–	–
14-1, 12	7.3	26	–	–

BIOSTRATIGRAPHY SUMMARY

General

The 15 cores obtained from Site 211 include sediment ranging in age from Quaternary to Late Cretaceous (Campanian).

Cores 1, 2, and 3 yielded well-preserved radiolarians. Cores 1 and 2 are Quaternary in age, and Core 3 is late Pliocene. The Pliocene/Quaternary boundary presumably occurs in the uncored intervals between Core 2 (18 meters) and Core 3 (57 meters).

Cores 4, 5, and 6 contain moderately well preserved radiolarian species which are indicative of a middle to late Miocene age. This assemblage is probably reworked, however, because the underlying material in Cores 7 through 9 appears to be younger.

Cores 7, 8, and 9 are no older than Pliocene in age, based on scattered specimens of *Sphaeroidinella dehiscens* within the sandy layers.

Cores 10 and 11 are barren of microfossils.

Core 12 contains nannofossils diagnostic of the late Campanian to early Maastrichtian.

Cores 13 and 14 are early to middle Campanian in age, also based on nannofossils.

Average rates of sediment accumulation in Cores 1 through 3 are 10 to 25 m/m.y. In Cores 4 through 9 the average accumulation rate appears quite high, in the range of 50 to 100 m/m.y. In Cores 12 through 14 the average accumulation rate is 3 m/m.y.

Foraminifera

The important Cenozoic assemblages occur in the sandy beds in Cores 7 through 9 and undoubtedly have been reworked from the shelf and slope. Specimens occur sporadically, but there is an overall consistency. Shallow-water tropical benthonics (*Pseudorotalia, Elphidium*) tend to be more battered than those from deeper water (*Bolivina, Uvigerina, Bulimina, Hyalinea, Oridorsalis*, etc.).

The planktonic pseudo-assemblages in Cores 7 through 9 indicate a maximum age of Miocene or younger: *Globigerinoides trilobus sicanus* (N.8-N.9, early Miocene); *Globorotalia tumida* s.s. (N.18, late Miocene); *Sphaeroidinella dehiscens* (N.19, early Pliocene). It is stressed that the consequent maximum age of early Pliocene for these sands, presumably turbidites, is based on single specimens of *Sphaeroidinella dehiscens* in each of Cores 7, 8, and 9, but that no other explanation (drilling or laboratory contamination) seems adequate. The source of this fossil material was tropical, where the range of *Pseudorotalia* is not well known, but its occurrence suggests an upper Miocene to Pliocene rather than an older age.

Foraminiferal assemblages in Cores 12 through 14 are characterized by (1) no planktonics, (2) both agglutinated and secreted-calcareous benthonics, (3) small size and preponderance of earlier ontogenetic stages in several instances, and (4) evidence of test thinning by carbonate solution. The presence of *Angulogavelinella praecaucasica, Alabamina dorsoplana*, and *Reussella* sp. indicates a correlation with the Korojon Calcarenite (Carnarvon Basin, West Australia) and a late Senonian to Maastrichtian age. Variations in the presence and amount of *Inoceramus* prisms are noteworthy.

With respect to the Korojon Calcarenite—the only useful comparison at present—these assemblages lack large *Gaudryina, Dorothia, Marssonella*, and large and strongly calcified anomalinids/gavelinellids and contain *Glomospira* in probably a more agglutinated overall character. All species are known from shelf sediments. Environmentally, it would seem that one is perhaps forced to choose between two extremes. The situation might have been inshore to the point where planktonic foraminifera were excluded, but not calcification by benthonics and *Inoceramus* (nor calcareous nannoplankton). There are precedents for this. However, no palynomorphs were found in a sample submitted to W. K. Harris, whereas response to H_2O_2 indicates the presence of organic matter. Alternatively, depth was sufficiently great to affect significantly the nannofossils and remove entirely the planktonic foraminifera by solution, but not several calcified benthonics (whether in situ or by downslope movement).

Nannofossils

Calcareous nannofossils were recovered only within the interval between the diabase sill and the volcanic basement. This interval is approximately 18 meters thick and consists of irregularly laminated, highly calcareous sediments of late Cretaceous age. The nannofossil assemblages are rather poor, owing, it appears, to selective solution of the majority of species. Relatively precise age assignments can be made because the index species, happily, seem to have been the most resistant to corrosion. The sediment recovered in Core 12, immediately beneath the diabase sill, has as its most abundant constituent the index species *Tetralithus nitidus trifidus*, indicating a late Campanian to early Maastrichtian age. Core 13 and the top of Core 14 contain essentially the same assemblage, except that *Tetralithus nitidus trifidus* is lacking. The presence of *Bronsoina parca*, however, indicates that the sediment is not older than the early to middle Campanian *Eiffellithus augustus* Zone. Apparently the transition between the two zones was lost between Cores 12 and 13, or alternatively, a hiatus separates the sediments of the two cores.

It is noteworthy that among the variegated laminae in Cores 12, 13, and 14, the light-colored (tan to pale yellow) laminae contain the largest number of recognizable nannofossils, while red and brown laminae generally contain few recognizable specimens. But even in the pale layers, complete nannofossils constitute only a small portion of the calcareous fraction, and by far the greatest percentage of the sediment consists of corroded, unrecognizable fragments of coccoliths.

This may be explained by assuming that the above sediments were deposited near the carbonate compensation depth and that most of the calcareous nannofossils were partially or completely dissolved. Only the forms most resistant to solution remained intact. This idea is supported further by the low accumulation rate for these sediments. If we assume that the 18 meters of sediment between basement and the diabase sill represent most of Campanian time (about 6 million years), a sedimentation rate of 3 m/m.y. is obtained. This rate is about one tenth of the accumulation rate for pelagic calcareous ooze, and some mechanism is required for removing a large part of the sediment. Selective solution of carbonate seems one possible explanation.

Radiolaria

Within Cores 1 and 2 the radiolarian assemblages consist of well-preserved specimens of *Lithopera bacca, Ommatartus tetrathalamus, Theocorythium trachelium, Eucyrtidium hexagonatum, Pterocanium praetexum*, and *Lamprocyclas maritalis maritalis.* The absence of *Pterocanium prismatium* indicates a Quaternary age for these two cores.

In Core 3 the presence of *Pterocanium prismatium*, in addition to the species of Cores 1 and 2, and the absence of *Stichocorys peregrina* indicate a late Pliocene age.

Cores 4 through 6 contain radiolarian assemblages which are poorly to moderately well preserved. The species most common in these cores are diagnostic of the middle to upper Miocene *C. petterssoni* and *O. antepenultimus* zones. However, the presence of scattered specimens of *Sphaeroidinella* sp. in the underlying Cores 7 through 9 (see discussion of foraminifera) suggests that Cores 4 through 6 may be Pliocene in age and that the Miocene forms are reworked. Hence, a Pliocene age is assigned to Cores 4 through 6.

CORRELATION OF REFLECTION PROFILE AND STRATIGRAPHIC COLUMN

Figure 4 illustrates the correlation between the generalized stratigraphic column of Site 211 and the airgun seismic reflection profile of the area. It is evident that the uppermost unit, a 95-meter-thick Quaternary-Pliocene siliceous ooze with ash beds, correlates well with the upper acoustically transparent zone on the seismic record. Below this the first major seismic reflector (1), which is rather broad and ill defined, correlates with the uppermost of a series of turbidite sands and silts. The underlying broad seismic reflector (2) lies within the turbidite sequence at 225 meters, with the intervening acoustically transparent zone possibly representing a more pelagic interval within the turbidites, with fewer sand beds. The acoustically transparent zone below the second reflector corresponds with a sequence of sands and brown, nonfossiliferous clays which are intruded at their base by a 10-meter-thick basaltic andesite sill. Seismic basement on the airgun record, broad and ill-defined in this area, probably represents this sill. The basal basalt is separated from the sill by approximately 18 meters of thinly bedded red-brown, clayey, nannofossil-bearing sediment which is not readily identifiable on the seismic record.

Depths of reflectors and interval velocities are as follows:

Reflector	2-Way Time (sec)	Depth (m)	Interval Velocity (km/sec)	
0	0	0		
			1.7	
1	0.11	95		
			2.1	2.0
2	0.24	225		
			2.1	
3	0.41	401.5		

SUMMARY AND CONCLUSIONS

The site for Hole 211 was selected approximately 3300 km west-northwest of Christmas Island and 1800 km south of the Java Trench. The hole, in a water depth of 5525 meters, was drilled in a basin of draped strata overlying ponded sediments. The surrounding topography is smooth except for a small seamount situated about 18 km to the south of the site.

The deepest lithological unit cored at Site 211, presumably oceanic basement, is a weathered, amphibole-bearing basalt which contains an unusual intercalated amphibolite in the form of a sill with chilled margins. This

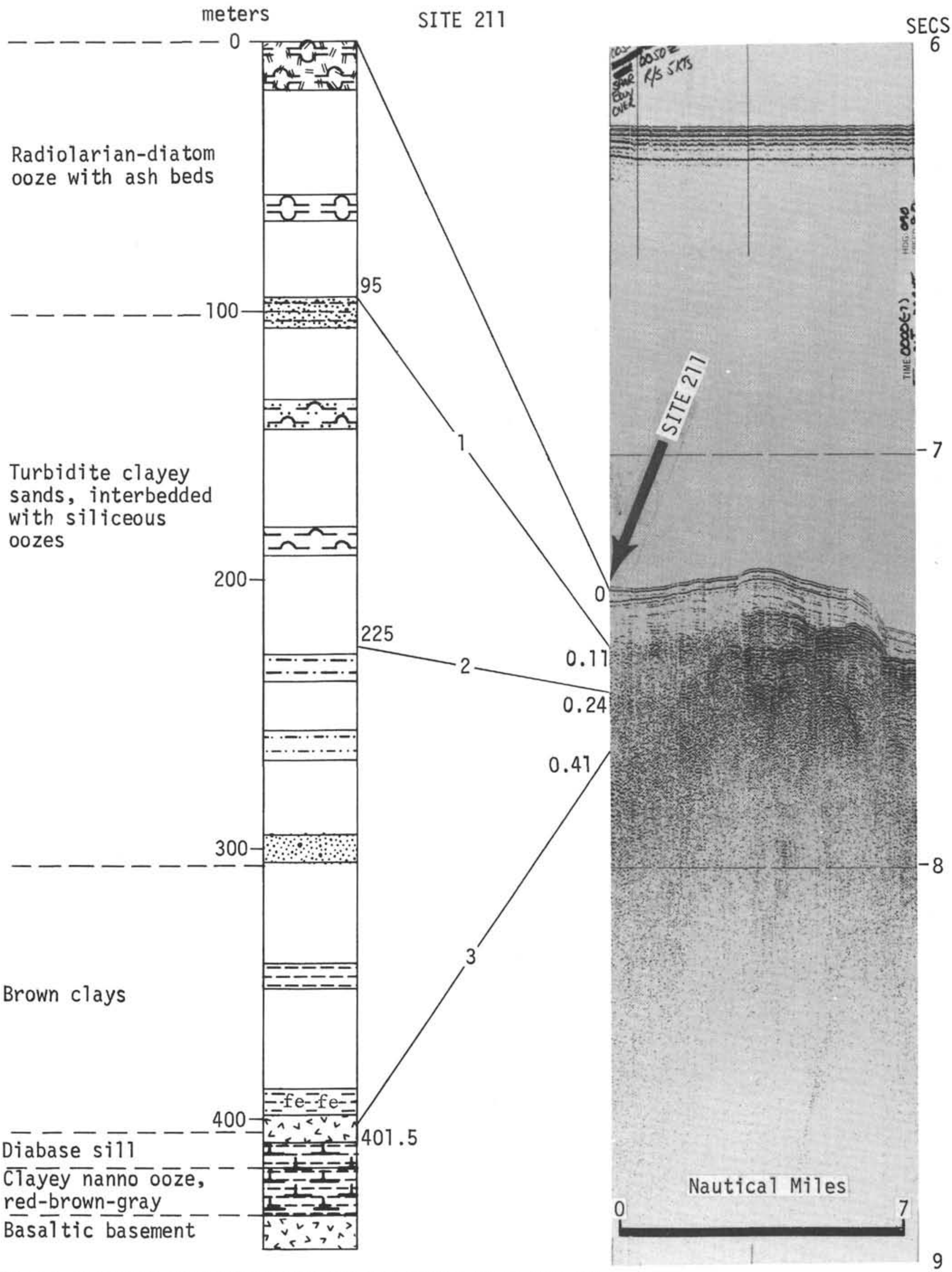


Figure 4. *Correlation of reflection profiles and stratigraphic column at Site 211.*

amphibolite is believed to be igneous and not metamorphic. The weathered amphibole-bearing basalts are considered to be extrusives, possibly pillow lavas which have been altered by the subsequent amphibolite intrusives as well as by submarine weathering processes.

The oldest sediment unit encountered at Site 211 is a variegated gray, cream and red-brown, nannofossil-bearing clay of early Campanian to Maastrichtian age which directly overlies the weathered amphibole-bearing basalt. These basal sediments, approximately 18 meters in thickness, have an irregular laminated structure and contain an impoverished assemblage of calcareous nannofossils and benthonic foraminifera. No palynomorphs have been found. Several thin (<1 cm) layers of apparently volcanogenic sand are distributed irregularly throughout the section.

A fresh diabase sill, 10 meters in thickness, has intruded the sediments 18 meters above basalt. Core recovery in the intruded sediments was poor, but they appear to vary from typical nonfossiliferous iron- and pyrite-rich deep-sea clays above to iron-rich nannofossil ooze below the sill. The mineralization of this unit may be related to the intrusion of the diabase.

Overlying the brown clay unit, at a sediment depth of about 300 meters, a series of micaceous silts and sands appears. These terrigenous sediments, interbedded with varying amounts of siliceous ooze, constitute a Pliocene sedimentary unit about 200 meters in thickness. The quartzose and feldspathic sands and silts contain abundant muscovite, biotite, and chlorite with a heavy mineral suite dominated by hornblende, epidote, garnet, tourmaline, sillimanite, and pyroxene. The mineralogy is suggestive of a continental provenance with a variety of rock types including granites, metamorphics, and volcanics. It is consistent with the sediments having been part of the Nicobar Fan during Pliocene times, as is the presence of reworked foraminifera of shallow-water origin. If the terrigenous sands and silts described above are indeed part of the Nicobar Fan and derived from the Ganges Brahmaputra effluent, then reason for the cessation of turbidite activity in the area within the Pliocene must be sought. The isolation from turbidite deposition could have been caused by damming to the north, which may have arisen by the closing of one of the gaps in the Ninetyeast Ridge against the Indonesian trench system. Alternatively, the formation of the pretrench rise associated with buckling of the Indian Plate as it descends into the Sunda trench could be the reason for the absence of turbidites.

The uppermost 100 meters of Site 211 consists of upper Pliocene to Quaternary radiolarian and diatom ooze with ash beds. This pelagic sediment represents oceanic deposition below the carbonate compensation depth. The ash deposits are of rhyolitic composition and most probably have come from the volcanically active Indonesian arc system to the north. As far as it can be deduced from the incomplete core recovery at this site, ash first appears in these sediments in the late Pliocene and may reflect onset of arc-type vulcanism at this time. On the other hand, the sediments may merely mark a shift of the oceanic crust into the proximity of the Indonesian arc during late Tertiary.

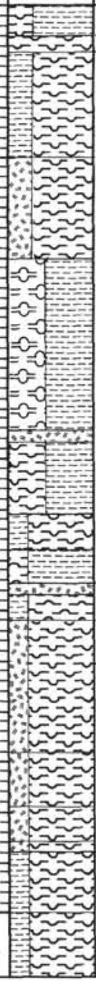
Magnetic anomalies 29 through the beginning of 33 trending east-west have been identified south of the Sunda Trench some 250 km N20°W of Site 211 (Sclater and Fisher, in preparation). These anomalies give a north-south spreading rate of 6 cm/yr. Assuming the same spreading rate of 6 cm/yr southwards from the beginning of anomaly 33 to the drilling site the age of oceanic crust in this area is estimated at 81 m.y. using the magnetic time scale of Heirtzler et al., 1968. This is close to the early to middle Campanian age (72 to 80 m.y.) of the sediments immediately above the basement.

REFERENCES

Heirtzler, J. R., Dickson, G. O., Herron, E. M., Pitman, III, W. C., and LePichon, X., 1968. Marine magnetic anomalies, geomagnetic field reversals, and motions of the ocean floor and continents: J. Geophys. Res., v. 73, p. 2119.

Sclater, J. G. and Fisher, R. L., in preparation. The evolution of the East Central Indian Ocean with emphasis on tectonic setting of Ninetyeast Ridge.

Site 211 Hole Core 1 Cored Interval: 0-9 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
QUATERNARY	(Unzoned)	R	F	G	1, 2, 3, 4	0.5, 1.0			10, 38, 42, 50, 25, 115, 15, 43, 62, 15, 125, 10, 86	
		R	C	G	5, 6					
		R	C	G	Core Catcher					

10YR4/4 — DIATOM RICH CLAY

2.5Y6/2 and 5YR3/2 — DIATOM OOZE

2.5Y4/2 — CLAY RICH DIATOM OOZE
dark grayish brown

5Y5/2

Diatoms	50%
Clay	25%
Spicules	15%

5Y4/2 — ASH RICH DIATOM OOZE
olive gray

Diatoms	50%
Rhyolitic Glass	25%
Spicules	20%
Rads	4%
Feldspar	1%

5Y6/2

5Y4/1 — RAD RICH CLAY

5Y6/2

Clay	65%
Rads	15%
Diatoms	10%
Spicules	5%
Silicoflag.	1%
Glass (green and clear)	3%
FeOxide	1%

2.5Y6/2 — COARSE ASH

5Y5/1

2.5Y7/0 — CLAY and RAD RICH DIATOM OOZE
light gray

5Y5/2 — RAD RICH CLAY

5Y8/2, 5Y4/2 — ASH white

5Y5/1 — RAD and ASH RICH DIATOM OOZE

CLAY and RAD RICH DIATOM OOZE

5Y4/2 streaked with 5Y2.5/1 — RAD and ASH RICH DIATOM OOZE

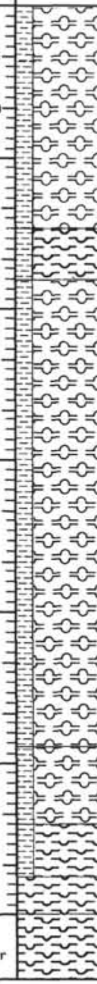
2.5Y5/0

5Y5/2 — CLAY and RAD RICH DIATOM OOZE
thin deformed ash layers with 90% silt and sand size glass

X-ray at 8.40 m Quar 30, Feld 2, Plag 8, Kaol 7, Mica 28, Chlo 2, Mont 24

Explanatory notes in Chapter 1

Site 211 Hole Core 2 Cored Interval: 9-18 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
QUATERNARY	(Unzoned)	R	C	G	1, 2, 3, 4	0.5, 1.0			105, 90, 60, 149	
		R	C	G	5, 6					
		R	F	M	Core Catcher					

5Y5/1 — CLAY RICH RAD DIATOM OOZE
olive

Diatoms	45%
Rads	35%
Spicules and silicoflag.	5%
Clay	15%

mottled 5Y5/1 and 5Y2.5/2 — CLAY SPONGE SPICULE RAD RICH DIATOM OOZE
olive and dark olive

5Y6/1 to 2.5Y4/0

Diatoms	60%
Rads	17%
Spicules	10%
Silicoflag.	3%
Clay	10%

2.5Y4/2 with 2.5Y4/0 and 2.5Y6/0 — pumice fragments

CLAY RICH SPONGE SPICULE DIATOM OOZE
dark gray brown with mottles and streaks of dark gray

Diatoms	40%
Spicules	25%
Clay	20%
Rads	10%
Silicoflag.	5%

granule-size pieces of consolidated ash

2.5Y4/2 with 2.5Y4/0 and 2.5Y6/0

2.5Y5/0 — CLAY RICH RAD DIATOM OOZE

5Y6/2, 5Y4/2 — ASH RICH DIATOM OOZE

5Y6/2, 5Y3/2

5Y2.5/2 — DIATOM OOZE

Diatoms	85%
Rads	5%
Spicules	5%
Clay	5%

Explanatory notes in Chapter 1

Site 211 Hole Core 3 Cored Interval: 57-66 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHO. SAMPLE
LATE PLIOCENE	Pterocanium prismatium				1	0.5, 1.0	50
		R	C	M	2		
					3		103
					4		
		R	C	G	5		129, 135
		R	C	G	Core Catcher		

LITHOLOGIC DESCRIPTION

Greenish gray 5GY6/1 with mottles and streaks of 5G2/1 and 5Y5/6 greenish black and light olive brown

SPONGE SPICULES DIATOM RICH CLAY

Clay and clay aggregates	63%
Diatoms	15%
Spicules	15%
Ash (rhyolitic)	1%
Silicoflag.	1%
Rads	3%
FeOxide and opaques	2%

transitional to

SPICULE RICH RAD DIATOM OOZE

Diatoms	40%
Rads	30%
Spicules	18%
Clay	10%
FeOxide and opaques	2%

5Y5/2-7/2 light olive gray to yellowish gray

ASH LAYERS

Rhyolitic glass shards	55-95%
Diatoms	0-15%
Clay	0-25%
Quartz, Feldspar, Heavy minerals	<5%

X-ray at 57.90 m Quar 24, Feld 4, Plag 11, Kaol 5, Mica 27, Chlo 3, Mont 26

Explanatory notes in Chapter 1

Site 211 Hole Core 4 Cored Interval: 95-104.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHO. SAMPLE
PLIOCENE	?	R	-		1	0.5, 1.0	1
		R	F	P	2		45, 85, 120
		R	-		3		25
		R F	C +	M G	Core Catcher		

LITHOLOGY: VOID (top of Section 1)

LITHOLOGIC DESCRIPTION

5Y4/1 to 5GY4/1

SILTY SAND
olive gray to dark greenish gray

Feldspar (mostly K-spar rare microcline, sodic plagioclase	48%
Mica	30%
Quartz	5%
Clay	10%
Sericite	3%
Heavy minerals	3%
Calcite	<1%

graded slightly sharp contacts
SILT layer
10GY5/2 grayish green with 5Y7/2 yellowish gray mottles of ash 5Y4/1

RAD SPICULE RICH CLAY
(50-90 cm, Section 2)
sand mottles 90-110 cm, Section 2

silt mottles

5Y4/1

CLAY with mottles of CLAYEY SILT and layers of greenish RAD RICH CLAY

X-ray at 97.20 m Quar 26, Feld 5, Plag 10, Kaol 3, Mica 38, Chlo 2, Mont 16

Explanatory notes in Chapter 1

Site 211 Hole Core 5 Cored Interval: 133-142.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	?				1	0.5, 1.0	VOID	105, 130	5YR6/4 — RAD CLAY, light brown
		R	F	M	1				
		R	F	M	2			120	5Y5/2 — CLAY RAD OOZE TO RAD RICH CLAY: light olive gray occasional mottles of dark gray (N3); hard layers 54-59, 90-94 cm; Rads 56%, Clay 40%, Heavy minerals 2%, Rhyolitic glass 1%, FeOxide 1%; Clay 80%, Rads 20%
		R	R	M	3				5Y5/2 and N3 — CLAY RICH RAD OOZE: light olive gray ooze badly mixed up with dark gray rad bearing fine sand, possibly former injected around latter
		R	+	M	4			135	N4 to N3 — RAD BEARING SILT: Feldspar (orthoclase) 63%, Clay 16%, Mica 15%, Rads 5%, Heavy minerals - hornblende, opaque, epidote 1%. N4 streaked with 5GY5/2 — dusky yellow green RAD OOZE
		R	F	M	5				X-ray at 141.20 m: Quar 23, Feld 4, Plag 10, Kaol 13, Mica 10, Mont 40
		R	F	M	6			10, 110	5Y5/2, pumice pebbles — CLAY RICH RAD OOZE: Rads 75%, Clay 15%, Diatoms 5%, Glass 3%, Silicoflag. 2%
		R	F	P	Core Catcher				

Explanatory notes in Chapter 1

Site 211 Hole Core 6 Cored Interval: 180.5-190 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	?				1	0.5, 1.0		44, 120	5Y2/1 — SANDY SILT, olive black. 5Y5/2 light olive gray streaked with N4 medium dark gray — PHILLIPSITE BEARING CLAY: Clay 85%, Rads 5%, Phillipsite 6%, Spicules 3%, FeOxide 1%
		R	R	M	2			140	10GY7/2 pale yellowish green — RAD CLAY: Clay 73%, Rads 25%, Other siliceous fossils 2%
					3			115	5Y5/2 — Clay 60%, Rads 30%
					4			58, 62, 66, 145, 10, 18	alternating CLAYEY SILT - SILTY CLAY and SILTY SAND, very fine - fine, may be drilling artifact - injection of softer silt around broken up sandier beds
		R	F	M	5				5Y7/2 yellowish gray mottled and streaked with 5Y4/1 olive gray — CLAY RAD OOZE: Rads 60%, Clay 35%, Other siliceous fossils 4%, Volcanic glass Tr.
					6				X-ray at 189.10 m: Quar 13, Feld 4, Plag 12, Kaol 12, Mica 9, Mont 50
		R	F	M	Core Catcher				

Explanatory notes in Chapter 1

Site 211 Hole Core 7 Cored Interval: 228-237.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	?	F	R	G	1	0.5, 1.0	VOID		90, 124	5GY4/1 dark greenish gray
		R	-							
					Core Catcher					

CLAYEY SILT - very watery, liner only partially filled

Feldspar	58%
Mica	10%
Clay	30%
Heavy minerals	2%

SANDY SILT - sand fine grain size, micaceous, some fragments silty clay

Feldspar	68%
Clay	20%
Mica	10%
Heavy minerals	2%

SILTY SAND - abundant fragments of silty clay.
In base of Section 1 rounded fragments of CALCAREOUS SILTSTONE - probably once part of indurated layer.

Calcite cement	65%
Feldspar	28%
Mica	5%
Heavy minerals	2%

Site 211 Hole Core 8 Cored Interval: 256.5-266 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	?	F	R	M	1	0.5, 1.0	VOID		100	10YR5/4; 5GY4/1
		R	-							
	N18 Maximum (F)				Core Catcher				CC	

CLAY
moderate yellowish brown

SANDY CLAYEY SILT

Feldspar	68%
Mica	10%
Clay	20%
Heavy minerals	2%

Explanatory notes in Chapter 1

Site 211 Hole Core 9 Cored Interval: 294.5-304 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
PLIOCENE	?				1	0.5, 1.0	VOID			N3
		F	R	M	2				132	
	N19 Maximum (F)	F	R	M	3				90	5Y4/1
		R	-							
					Core Catcher					

SILTY CLAY with sand layers
medium dark gray

SILTY SAND
olive gray

Feldspar	80%
Mica	3%
Clay	15%
Heavy minerals of hornblende - epidote suite	2%

Explanatory notes in Chapter 1

Site 211 Hole Core 10 Cored Interval: 342-351 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
?	?	R	-		1	0.5, 1.0			
					2				
					3				
					4				
					5				
					6				
					Core Catcher				

LITHOLOGIC DESCRIPTION

Core Catcher and Part of Section 1 contained:

1) SILTY CLAY
5YR4/4 moderate brown

Quartz	3%
Feldspar (2% plag.)	10%
Mica	1%
Heavy minerals (inc. amphibole)	1%
Clay minerals	85%

2) CLAY
10YR2/2 dusky yellowish brown

Feldspar	9%
Mica	1%
Clay minerals	75%
Iron aggregates	15%
Rads and fish remains	Tr.

3) SILTY SAND
5Y4/1 olive gray, believed to be cavings from up hole.

X-ray at 351.00 m Quar 16, Feld 8, Plag 2, Kaol 21, Mica 8, Chlo 1, Mont 42

Explanatory notes in Chapter 1

Site 211 Hole Core 11 Cored Interval: 389.5-398 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
?	?	R	-		1	0.5, 1.0			
					2				
					3				
					4				
					5				
					6				
					Core Catcher				

LITHOLOGIC DESCRIPTION

Core Catcher Samples only

About 9 cm of stiff moderate brown (5YR3/4) clay rich iron oxide. Also few small (1 x 3 cm) fragments of hard bedded red and dark gray mineralized samples. Three facies identified as follows:

1) brown AMORPHOUS IRON OXIDE facies

Iron oxide	70%
Clay	20%
Heavy minerals, Feldspar, glass shards	10%

2) dark gray PYRITE-RICH ASH facies
- 80% devitrified glass shards originally of basaltic composition (clear rims with R.I. >1.55) now almost totally filled with brown iron oxide. Few (1%) grains are yellow-palagonitized?
- 10% opaques - mostly pyrite, some cubes seen
- 9% micronodules - abundant minute iron oxide grains scattered throughout
- 1% feldspar - some plagioclase identified

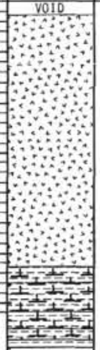
3) red ASH-RICH IRON OXIDE facies
- 90% iron oxide aggregates several of which are definitely hematitic.
- 10% altered glass shards - much of FeO has probably replaced glass shards as few pale brown shards with FeO do remain - also FeO aggregates occasionally still have clear isotropic rim.
- Tr. feldspar
- Tr. crystoballite (?) aggregates

X-ray at 398 m Quar 13, Feld 36, Kaol 2, Mica 13, Chlo 1, Mont 15, Paly 17, Hema 4

Explanatory notes in Chapter 1

Site 211 Hole Core 12 Cored Interval: 409-418.5 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
LATE CAMPANIAN TO EARLY MAESTRICHTIAN	Tetralithus nitidus trifidus Zone	N	C	P	1, 2	0.5, 1.0	VOID		124, 140, 149
		N F R	C C -	P M	Core Catcher				10, 27



LITHOLOGIC DESCRIPTION

"ANDESITIC" Sill (Diabase)
greenish black uniform composition
see below

5GY2/1

Alterations of NANNO RICH CLAY and CLAY NANNO OOZE
gradational contacts,
iron rich below andesite

finer grained ("basaltic")

5Y5/2 Weathered zone

5R3/4 dusky red

Nannos	10-50%
Feldspar	1- 3%
Heavy minerals	1%
Clay	50-80%
Dolomite rhombs	<1%

5YR6/4 10YR7/4 gradational light brown to gray orange

10YR2/2 dusky yellow brown
5YR6/4 and 10YR7/4
10YR2/2

Thin Sections

Section 1, 143 cm HOLOCRYSTALLINE PHANERITIC ROCK with subophitic texture

Plagioclase (sodic plag. <An_{30} calcic andesine An_{48-50})	55%
Clinopyroxene - purplish augite	20%
Heavy minerals	6%
Mica (brown biotite)	4%
Chlorite	8%
Zeolite	2%
Amphibole	1%
Sericite	3%
Epidote	1%

Section 2, 114 cm HYPOCRYSTALLINE APHANITIC ROCK with intersertal texture

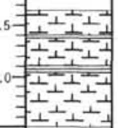
Plagioclase (andesine-labradorite An_{46-53} sodic plag. <An_{30})	39%
Clinopyrox. - as above	25%
Heavy minerals (hematite, magnetite)	10%
Mica	2%
Chlorite	5%
Glass	1%
Palagonite	8%
Calcite	10%

X-ray at 409.10 m Calc 34, Quar 8, Feld 12, Kaol <1, Mica 5, Chlo 1, Mont 2, Paly 38
X-ray at 411.80 m Calc 35, Quar 15, Feld 29, Mica 14, Hema 7
X-ray at 411.90 m Calc 81, Quar 5, Feld 7, Mica 7

Explanatory notes in Chapter 1

Site 211 Hole Core 13 Cored Interval: 418.5-428 m

AGE	ZONE	FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
EARLY TO MIDDLE CAMPANIAN	Eiffellithus augustus Zone	N	C	P	1	0.5, 1.0	VOID		61, 116.5, 120, 127
		R F N	- C C	M P					
					Core Catcher				



LITHOLOGIC DESCRIPTION

MICARB RICH NANNO OOZE
Variegated red (10R6/6), cream (10YR8/2) and gray (5Y4/1) - latter predominant.

Nannos	70-80%
Micarb	10-15%
Feldspar	5%
Heavy minerals	2%
Dolomite rhombs	1%

Hematite grains ~20μ more common in red layers

IRON-RICH ASH

Sand	50%
Silt	50%

Brown (10YR5/4) layers ≤ 4 mm thick at 59, 95, 97, and 98 cm. 60% volcanic glass strongly altered with some incipient plagioclase and palagonite; 20% heavy minerals - goethite or limonite aggregates, some hematite

Feldspar	8%
Nannos	10%
Mica	2%

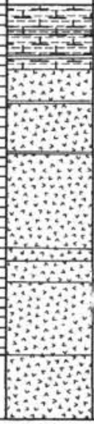
Bedding: 1 to 5 mm thick, many beds have wavy (rippled?) contacts, some beds locally erode those below, microfaulting in places, some mottles and a burrow in 40-50 cm interval.

X-ray at 418.60 m Calc 33, Quar 9, Feld 15, Mica 4, Mont 10, Paly 28
X-ray at 419.50 m Calc 35, Quar 6, Feld 6, Mica 6, Paly 47

Explanatory notes in Chapter 1

Site 211 Hole Core 14 Cored Interval: 428-437.5 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
EARLY TO MIDDLE CAMPANIAN	Eiffellithus augustus Zone	R F N	- C C	M P	1	0.5 1.0			30 65
					2				
					Core Catcher				



LITHOLOGIC DESCRIPTION

CLAY RICH NANNO OOZE and NANNO CLAY laminated

10R6/6 moderate yellowish orange		10YR2/2 dusky yellowish brown	
Nannos	72%	Clay	40%
Clay	15%	Nannos	39%
Feldspar	10%	Feldspar	10%
Dolomite	3%	Dolomite	10%
		Heavy minerals	1%

Two beds of moderate brown 5YR5/6 nanno clay indicated actual contact lost in coring

BASALT weathered pillow lava

Texture varies from aphanitic to phaneritic veins (1-3 mm) and amygdales of calcite common - some shown on log to left also indicated in same way are patches of palagonitized glass

Phaneritic	60- 90 cm
Amygdaloidal Zone	60-102 cm
Aphanitic Zone (very fine)	105-120 cm
Aphanitic (fine)	120-150 cm (Section 2)
	0- 50 cm (Section 3)

glassy groundmass

5 cm fragment of baked limestone with fragments of black glass and pale brown palagonite embedded in it

Thin Sections

Section 2, 60 cm PHANERITIC BASALT: hyalopilitic texture

Plagioclase (An_{45}-An_{55}) and albitized plagioclase	48%
Altered pyroxene	10%
Titanomagnetite and hematite	8%
Olivine ghosts	5%
Calcite	8%
Dark mesostasis	10%
Volcanic glass and palagonite	10%
Zeolite	1%

Core Catcher, 1 cm APHANITIC BASALT: variolitic texture

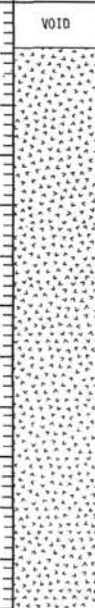
Plagioclase laths (radiating clusters)	30%
Dark mesostasis	20%
Cryptocrystalline aggregates of devit. glass	10%
Olivine crystal outlines altered into iddingsite	5%
Hematite, titanomagnetite	15%
Volcanic glass	15%
Palagonite	5%

X-ray at 428.10 m Calc 3, Dolo 6, Quar 13, Feld 9, Paly 69

Explanatory notes in Chapter 1

Site 211 Hole Core 15 Cored Interval: 437.5-447 m

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	ABUND.	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE
					1	0.5 1.0	VOID		
					2				
					3				
					4				
					Core Catcher				



LITHOLOGIC DESCRIPTION

BASALT flow
aphanitic, glassy matrix
partially palagonitized,
sporadic large amygdales

phaneritic
aphanitic — palagonitized crust mixed with calcite
polygonal outline (chilled contact of flow?) of weathered material may be palagonite
aphanitic — palagonitized crust, calcite, and fresh glass
calcite
aphanitic — palagonitized crust (chilled margin?) with veins of calcite in center
transition — palagonitized zone - incipient crystallization polygons seen
aphanitic
calcite
aphanitic becoming coarser downwards

transition — palagonitized zone

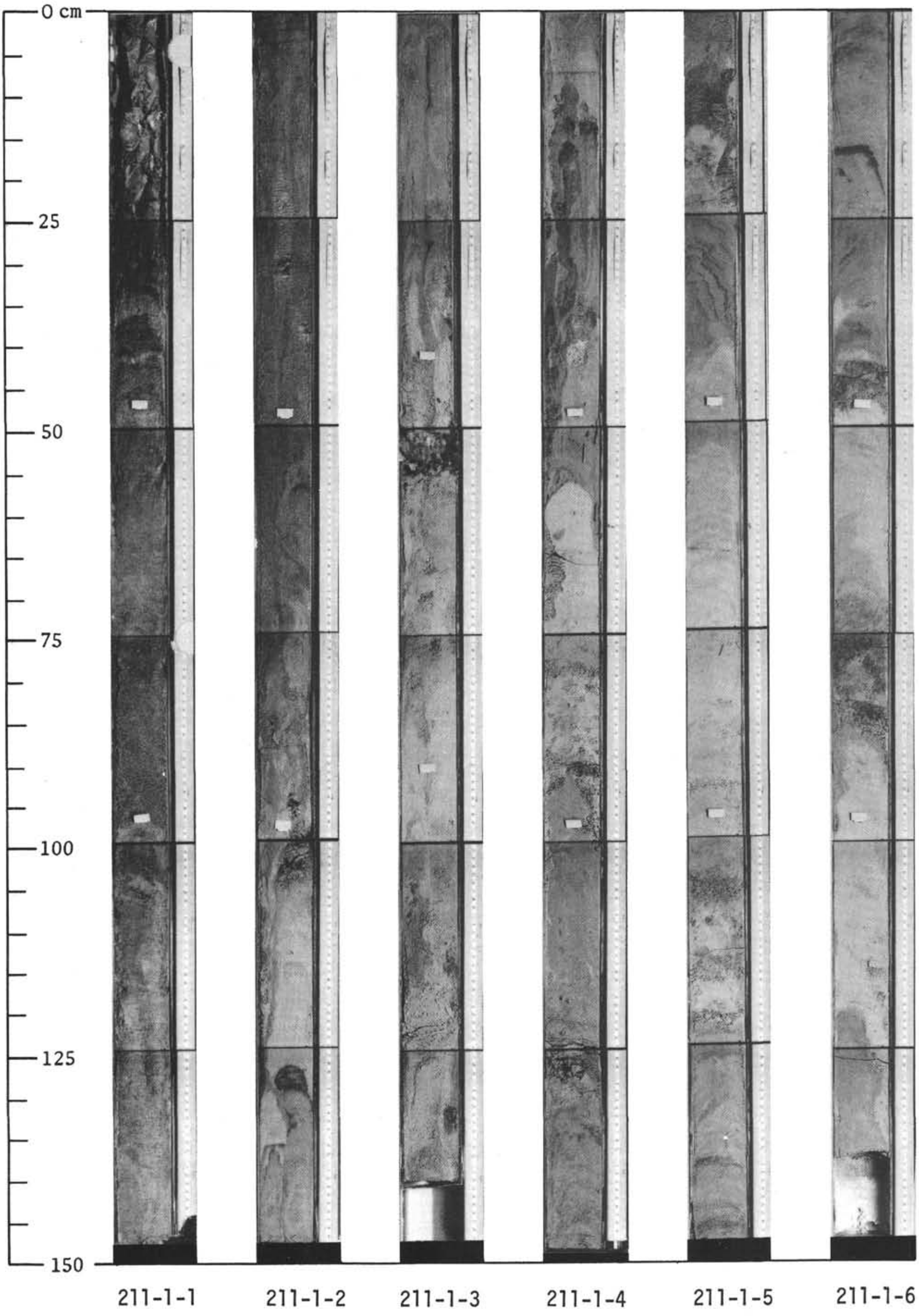
calcite veins
large amygdales (<3 mm) — phaneritic zone
calcite vein

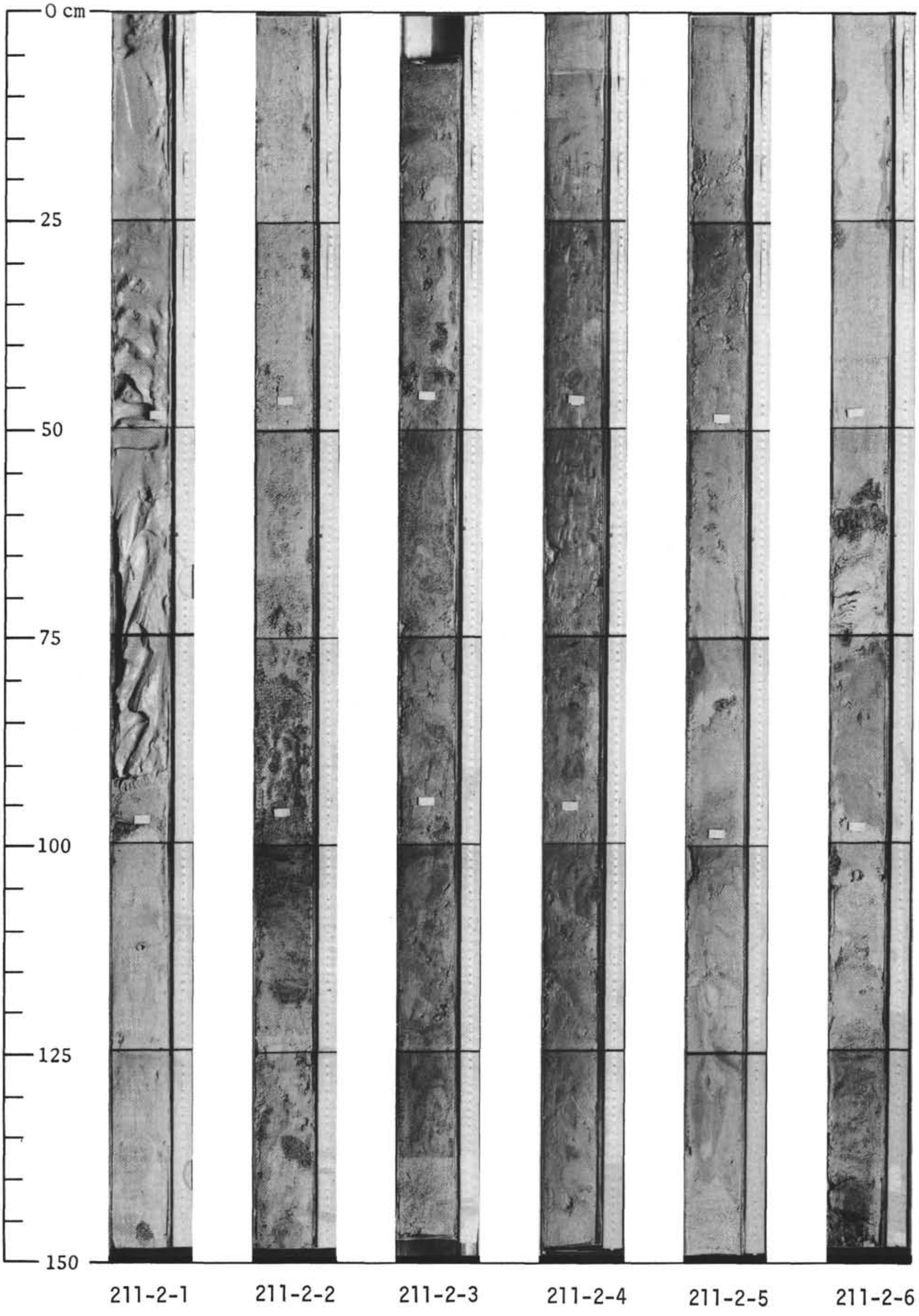
aphanitic
highly weathered
calcite vein
calcite and palagonite — phaneritic zone
large amygdales and
patches of calcite

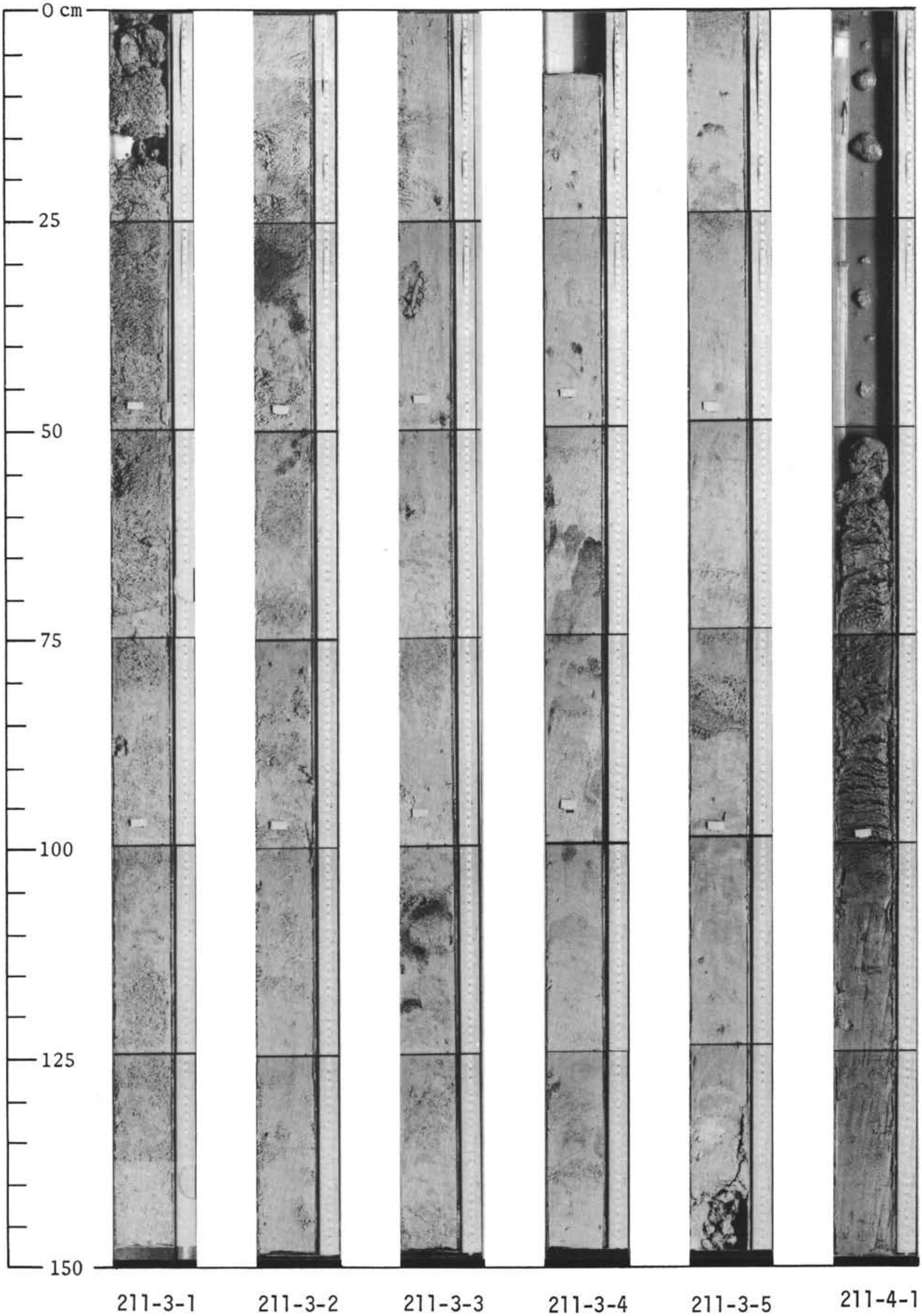
highly weathered — aphanitic zone
calcite veins 2-4 mm

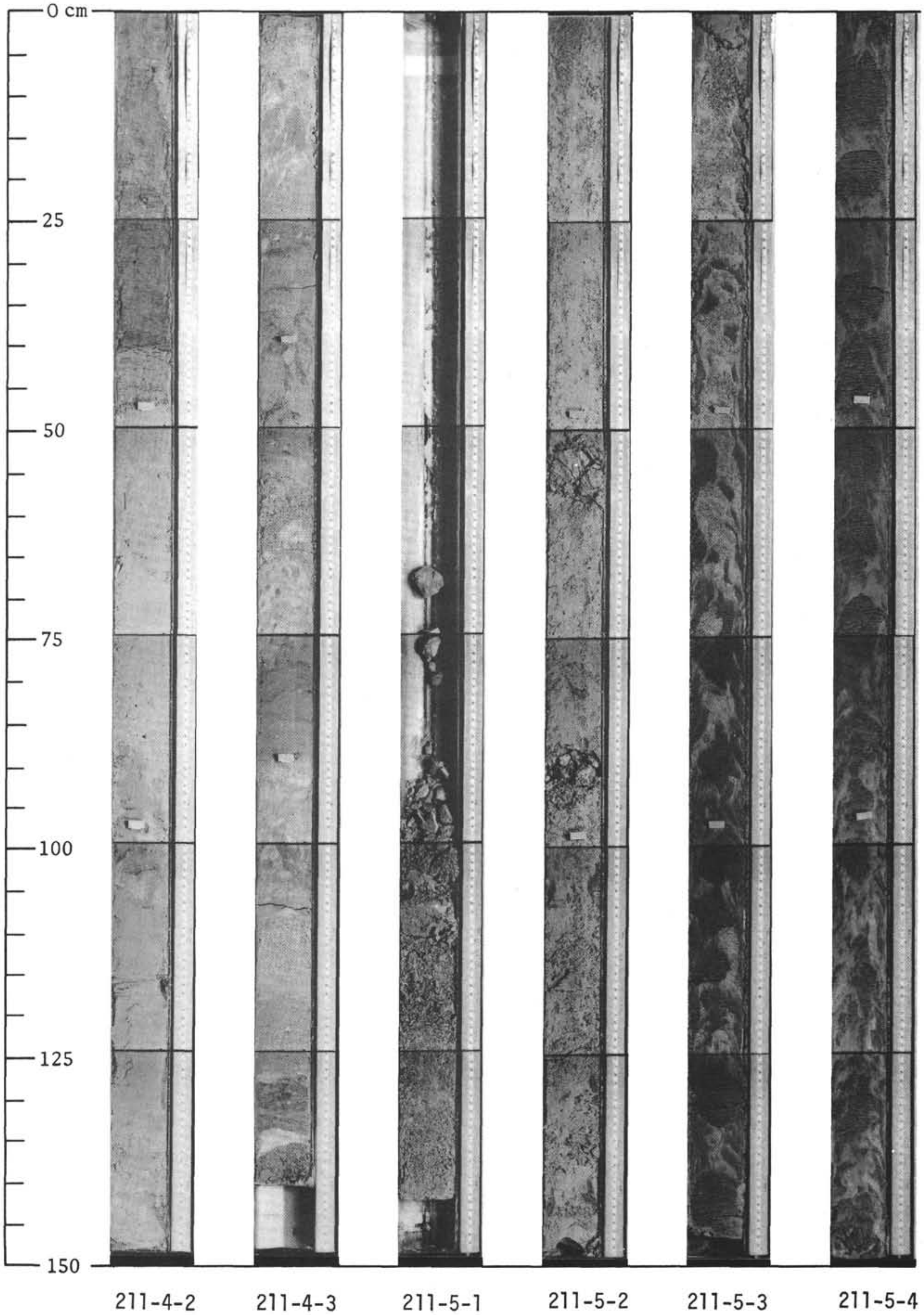
phaneritic zone

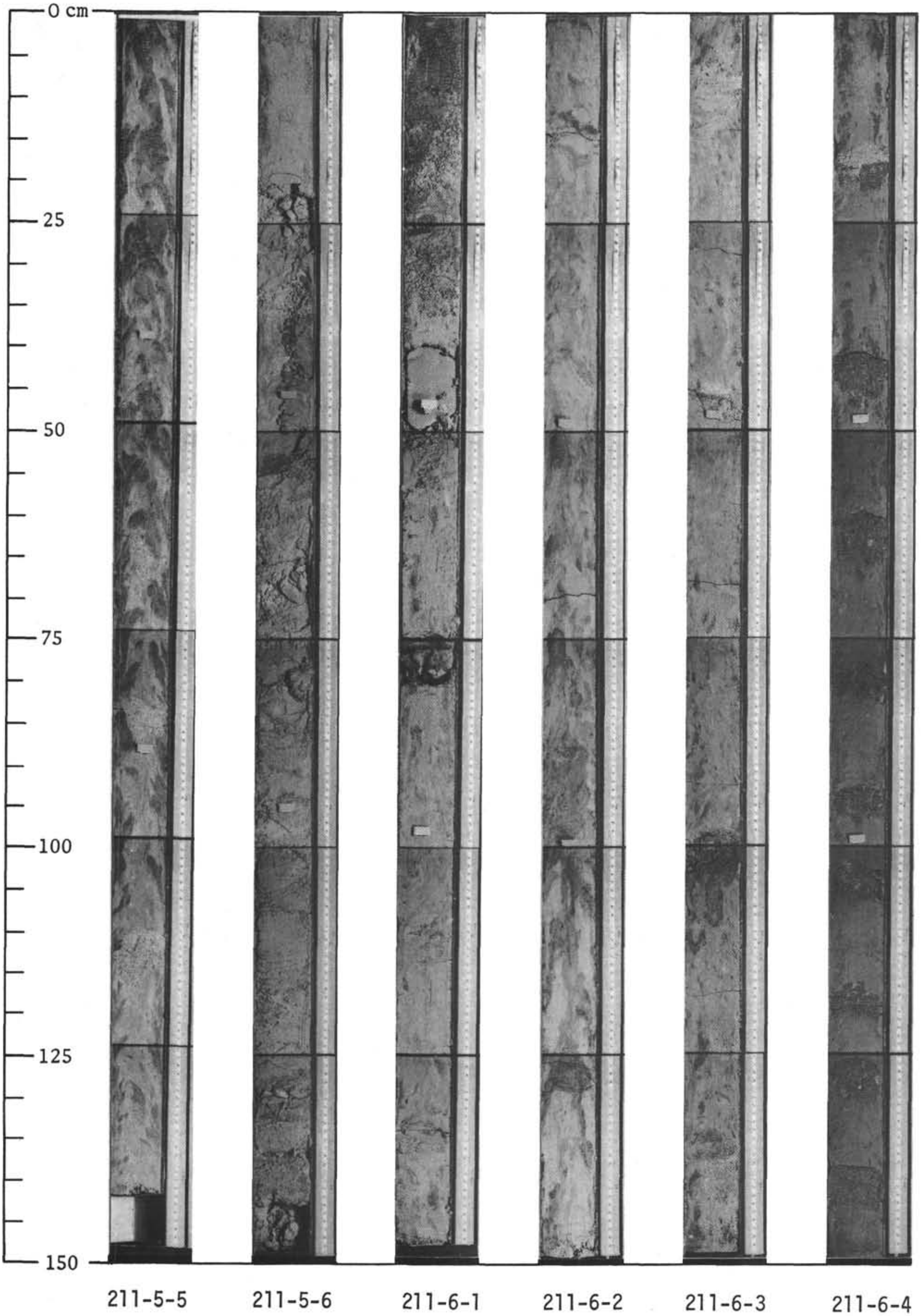
Explanatory notes in Chapter 1

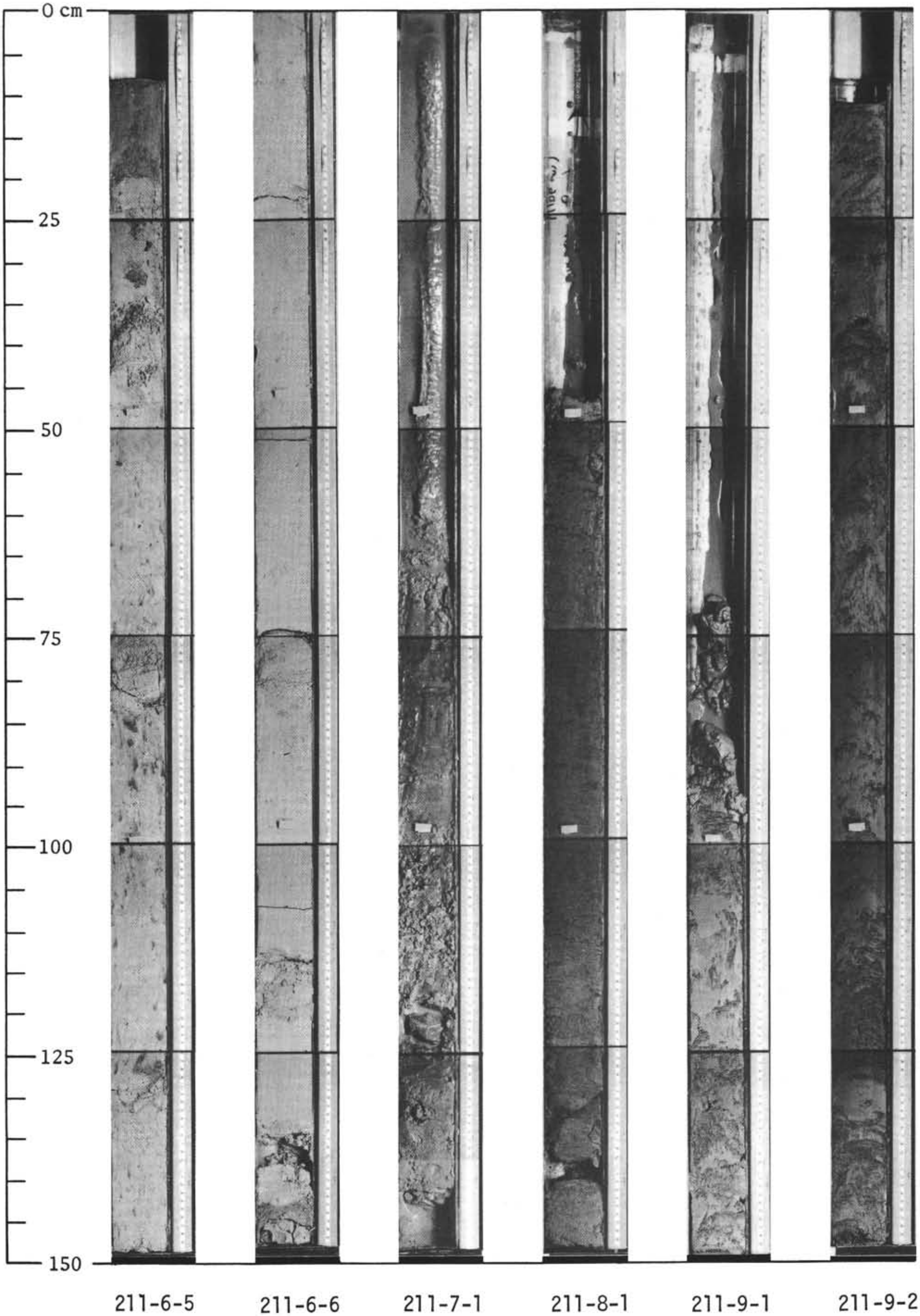

0 cm
25
50
75
100
125
150
211-1-1
211-1-2
211-1-3
211-1-4
211-1-5
211-1-6

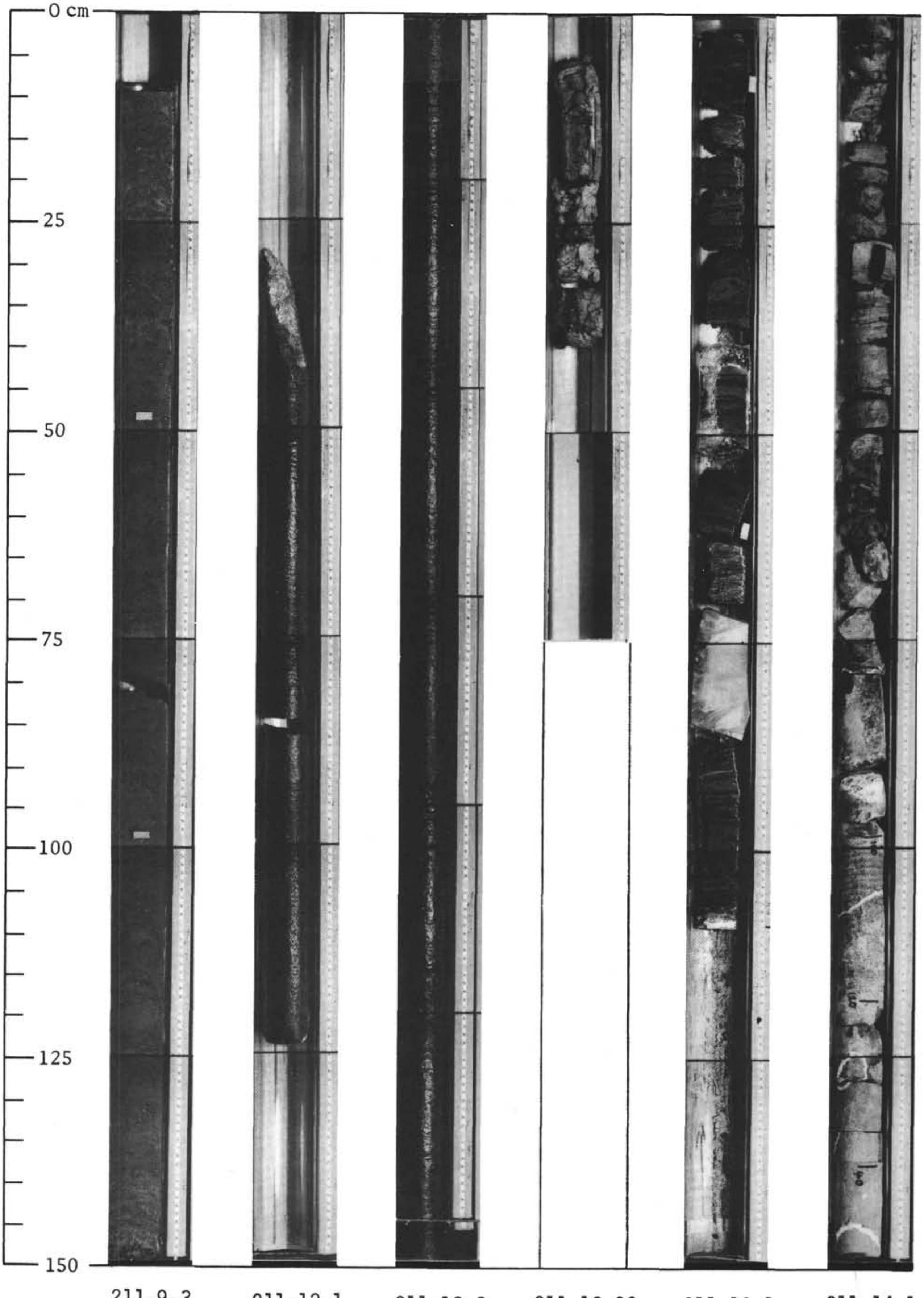

0 cm
25
50
75
100
125
150
211-2-1
211-2-2
211-2-3
211-2-4
211-2-5
211-2-6

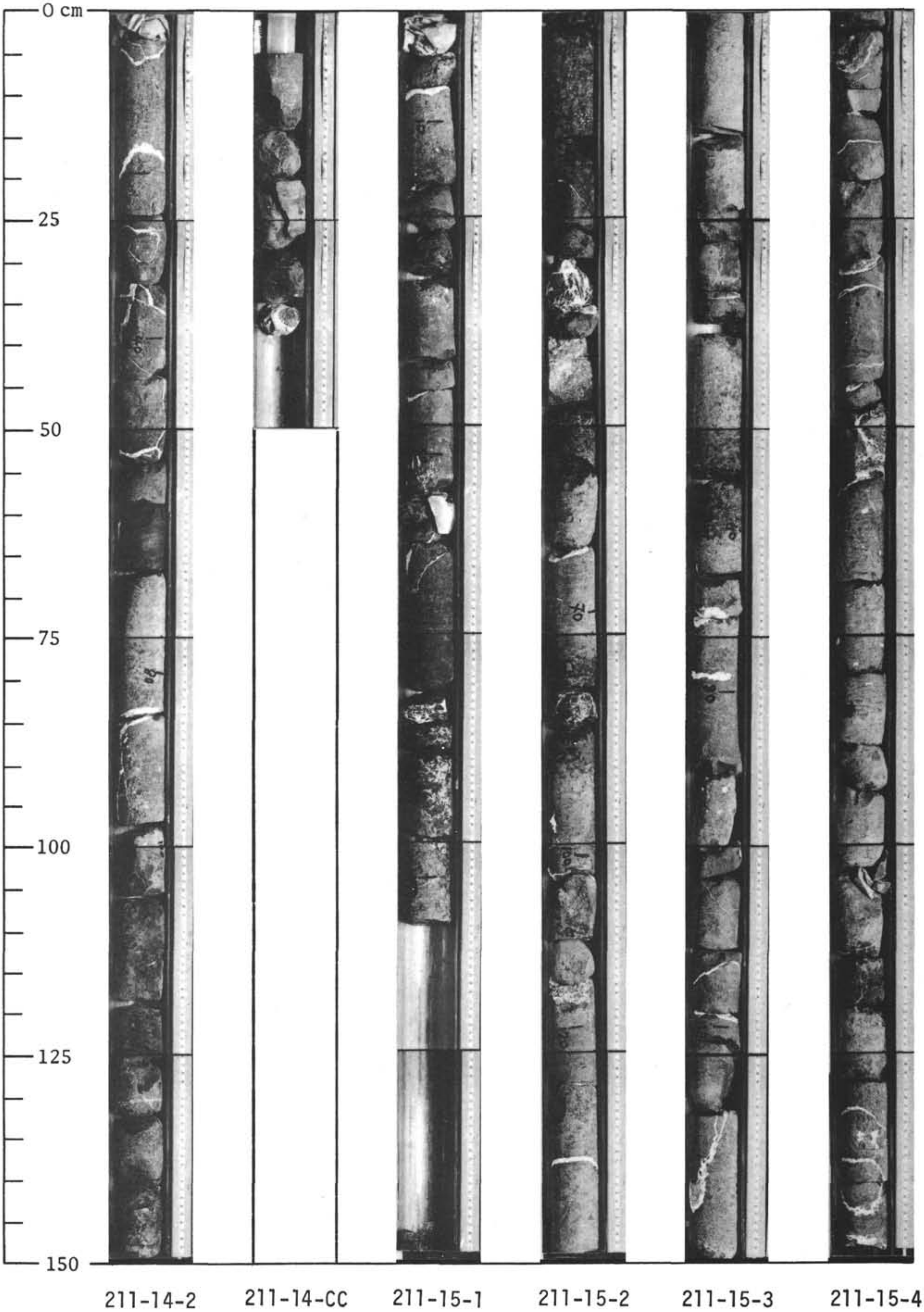

0 cm
25
50
75
100
125
150
211-3-1
211-3-2
211-3-3
211-3-4
211-3-5
211-4-1


0 cm
25
50
75
100
125
150
211-4-2
211-4-3
211-5-1
211-5-2
211-5-3
211-5-4


0 cm
25
50
75
100
125
150
211-5-5
211-5-6
211-6-1
211-6-2
211-6-3
211-6-4


0 cm
25
50
75
100
125
150
211-6-5
211-6-6
211-7-1
211-8-1
211-9-1
211-9-2


0 cm
25
50
75
100
125
150
211-9-3
211-12-1
211-12-2
211-12-CC
211-13-1
211-14-1


0 cm
25
50
75
100
125
150
211-14-2
211-14-CC
211-15-1
211-15-2
211-15-3
211-15-4