13. SITE 302

The Shipboard Scientific Party[1]

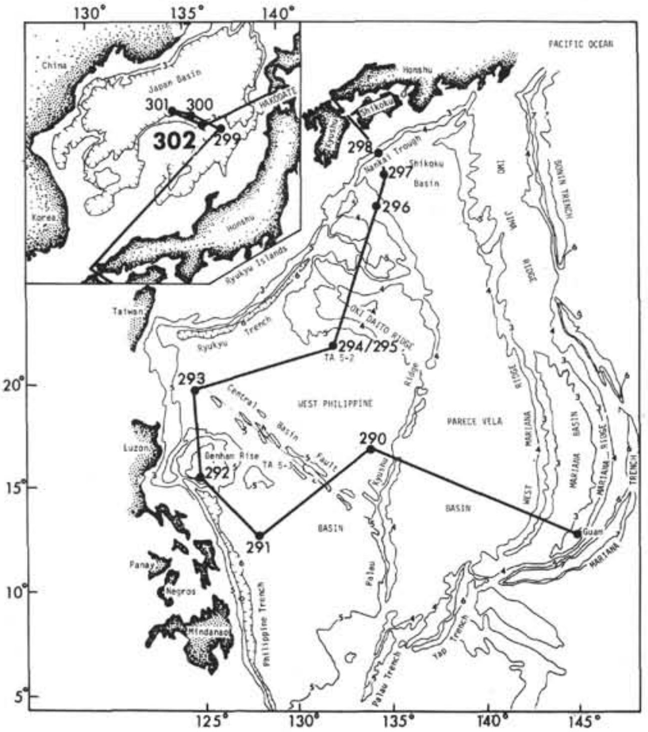

Figure 1. *Location map of DSDP sites and* Glomar Challenger *tracks in the Sea of Japan. From map: "Topography of North Pacific," T. E. Chase, H. W. Menard, and J. Mammerickx, Institute Marine Resources, Geol. Data Center, Scripps Institution of Oceanography, 1971. Contour depths in kilometers. Scale 1:6,500,000.*

SITE DATA

Position: 40°20.13'N; 136°54.01'E

Water Depth (from sea level): 2399 corrected meters (echo sounding)

Bottom Felt At: 2414.5 meters (drill pipe)

Penetration: 531.5 meters

Number of Holes: 1

Number of Cores: 18

Total Length of Cored Section: 164.5 meters

Total Core Recovered: 91 meters

Percentage of Core Recovery: 55.3%

Oldest Sediment Cored:
Depth below sea floor: 531.5 meters
Nature: Silty sand and green tuff
Age: Late Miocene

Principal Results: Site 302 was drilled on the northern end of Yamato Rise in the central part of the Sea of Japan. The stratigraphic section recovered consists of about 28.5 meters of Pleistocene clayey diatom ooze and ash, 38(?) meters of Pleistocene zeolitic clay and micarb, 281.5 meters of late Pliocene-late Miocene diatomaceous ooze, 177 meters of Miocene zeolitic clay, and 2 meters of early Miocene(?)-unfossiliferous silty volcanic sand and green tuff. Diatom zonation indicates all of the late Pliocene is absent from this sequence and a major unconformity is tentatively placed at the base of Core 5 (76 m). Due to medical emergency, had to rapidly drill to acoustic basement with only three cores pulled below 275 meters. Upper half of column represents good siliceous biostratigraphic reference section with dominantly boreal biofacies. Reworked (?) Oligocene nannofossils and green tuffs at base of hole tend to support mid-Tertiary opening of sea.

BACKGROUND AND OBJECTIVES

Background

After being forced to abort Hole 301 because of critical shows of ethane, we wanted to seek a site which would yield maximum information regarding the history of the Japan Abyssal Plain area in the limited time remaining before Leg 31 was scheduled to terminate in Hakodate. Because of the unxpected gas conditions seemed to be associated with the high heat flow in the basins, and because time was waning, we concluded that the flanks of Yamato Rise presented the only logical target. There, heat-flow values approach normal, and the pelagic cover appeared to be similar to and continuous with that in the basin. Basement undoubtedly was different than beneath the Japan Abyssal Plain area; however, we decided that by drilling in a local low it might be possible to penetrate rocks representing an earlier subsidence history of the rise.

The Yamato Rise is an elongated complex of ridges extending north and clockwise from southwest Japan (Figures 1 and 2). Two particularly prominent ridges, Kita-Yamato Ridge and Yamato Ridge, form the bulk

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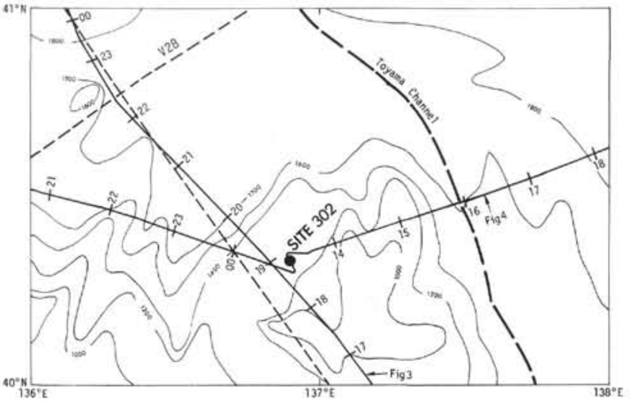

Figure 2. *Bathymetry (in uncorrected fathoms in the vicinity of Site 302 updated from Chase and Menard (1969) using* Glomar Challenger *and LDGO* (Vema-*28*) *data. Toyama Channel is located using these data.*

of the rise and are separated by Yamato Trough. A varied suite of rocks, including late Mesozoic volcanics and intrusives, as well as Tertiary volcanics and sediments has been dredged from the crest of the rise (Iwabuchi, 1968). Together with seismic refraction profiles (Murauchi and Yasui, 1968), these data demonstrate the continental affinities of Yamato Rise.

Underway *Glomar Challenger* seismic profiles as well as an on-site sonobuoy record and earlier *Vema*-28 (LDGO) records all demonstrate that the flanks of Yamato Rise are covered by a 0.3 sec unit of transparent sediment draped across ridges and troughs (Figures 3 and 4). This unit is underlain by a series of beds displaying decreasing reflectivity with depth with acoustic basement at 0.5 sec (Figure 3). The upper transparent layer can be traced down the flanks of the rise as it dives beneath the younger turbidite fill of the adjacent basins penetrated at Site 301 and determined to be of Plio-Pleistocene age.

Objectives

Selection and ultimate attainment of objectives at Site 302 were tempered by severe time limits and an unexpected medical emergency aboard *Glomar Challenger.* Study of all available seismic reflection profiles in the vicinity of Yamato Rise together with the limited stratigraphic data from Site 301 indicated that drilling on the rise flank at Site 302 offered an excellent opportunity to recover a relatively undisturbed section through the diatomaceous pelagic unit, which remained just beyond the drill at Sites 299 and 301. Moreover, the underlying series of weak reflectors above final acoustic basement was thought to possibly represent a volcaniclastic apron on the northwest side of the rise, now deeply buried. Thus, drilling at Site 302 also offered the possibility of sampling an older volcanic sequence of possibly Tertiary or even late Mesozoic age overlying the basement core of late Paleozoic age known from dredging on the rise (Iwabuchi, 1968). The bathymetric isolation of the rise was particularly attractive from a biostratigraphic viewpoint, and it was anticipated that well-preserved siliceous and possibly calcareous planktonic assemblages might be recovered on the rise flank.

OPERATIONS

The location of Site 302 (Figure 1) which seemed to fit the revised objectives was noted on the seismic reflection profile between Sites 299 and 300. The actual site was in a local depression on the northwest flank of the Yamato Rise (Figure 2).

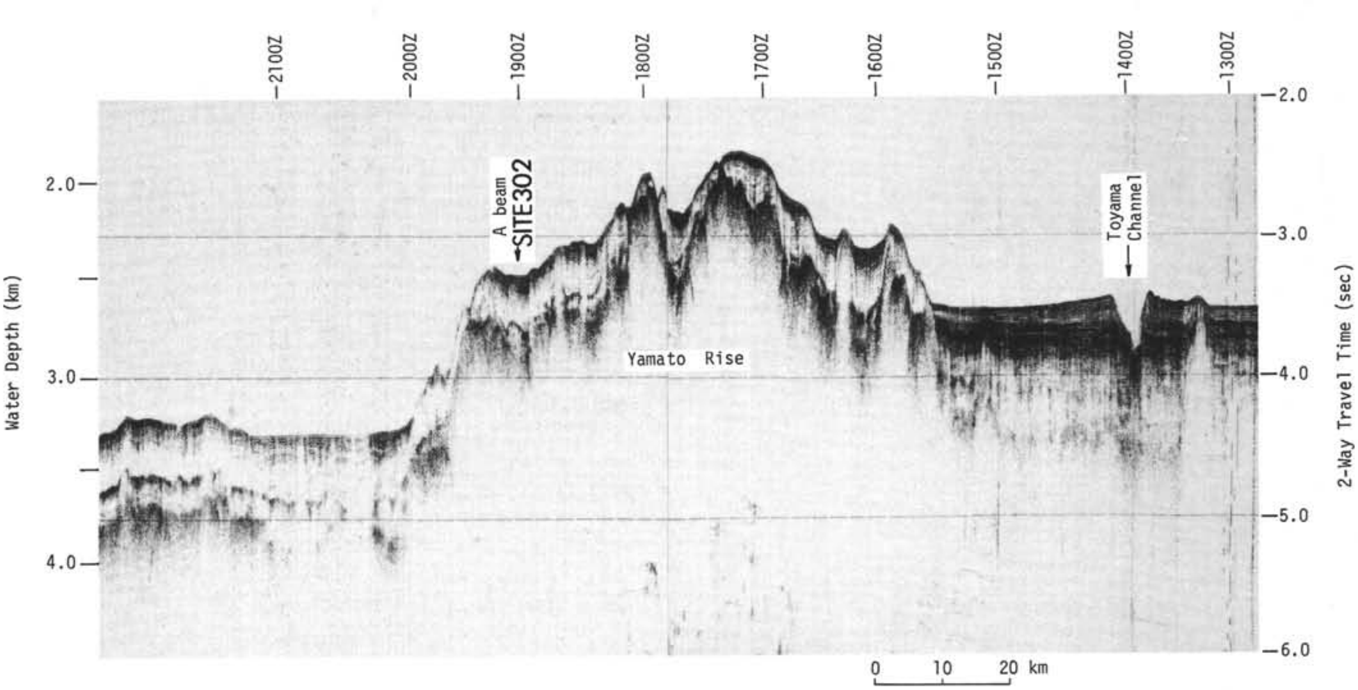

Figure 3. Glomar Challenger *seismic reflection profile from Site 299 to 300 through Site 302. Note continuity of pelagic section of the Japan Basin with the pelagics on the Yamato Rise flanks.*

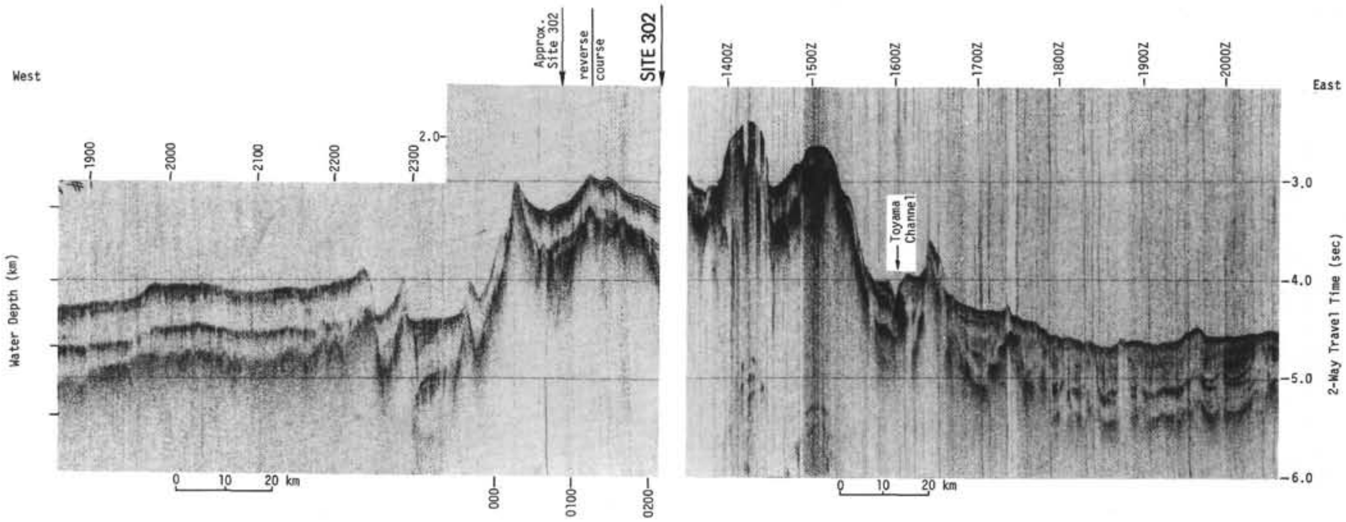

Figure 4. Glomar Challenger *seismic reflection profile approaching and departing Site 302.*

The track to Site 302 did not include survey time other than a reduction in speed to 6 knots as the ship intersected the previous track. The new course followed its reciprocal (140°) to the desired position. Because the profile was not identical with that obtained earlier, a location was chosen on the new profile (Figures 3, 4).

A 16-kHz beacon was dropped at 1100 LCT, 2 August. The lack of an interface between the computer and the vertical reference gyro system required the use of semiautomatic positioning mode for the entire hole. The drill string was lowered at 1120, and Hole 302 was spudded in 2414.5 meters of water (by drill pipe).

Sampling began with an alternating core and drill sequence which was to be switched to continuous coring through the anticipated Miocene diatomaceous ooze. No problems with hole conditions or with gas content developed, except for decreasing core recovery after 225 meters (Table 1).

However, a medical emergency necessitated a coring program change to accommodate an early termination of Leg 31. The only program which could be devised under these circumstances was to attempt to drill rapidly to basement sampling the section with three critically located cores which would utilize all the time available. If the medical decision allowed remaining on site, it would be possible to core into basement, and time would be available to respud and core the missed intervals.

A sharp reduction in drilling rate at 528 meters prior to cutting the third core (Core 18) indicated basement (Figure 5), and Core 18 was taken. Less than 1 meter of rock was retained in the core, probably representing the hardest part of the 63-meter drilled interval, but volcanic tuff in the core catcher undoubtedly represented basement (Table 1). At this time the medical situation had not improved, and a decision was reached to abandon the site and steam directly to Hakodate. After filling the hole with 150 barrels of heavy mud as a precautionary measure, the site was abandoned, and at 2200, 3 August the ship was underway to Hakodate.

TABLE 1
Coring Summary,[a] Site 302

Core	Cored Interval Below Bottom (m)	Cored (m)	Recovered	
			(m)	(%)
1	0.0-9.5	9.5	0 (CC)	0.0
Wash	9.5-19.0			
2	19.0-28.5	9.5	8.2	86.0
Wash	28.5-38.0			
3	38.0-47.5	9.5	9.5	100.0
Wash	47.5-57.0			
4	57.0-66.5	9.5	7.5	79.0
Wash	66.5-76.0			
5	76.0-85.5	9.5	6.9	73.0
Wash	85.5-95.0			
6	95.0-104.5	9.5	0 (CC)	0.0
Wash	104.5-114.0			
7	114.0-123.5	9.5	9.5	100.0
Wash	123.5-133.0			
8	133.0-142.5	9.5	9.5	100.0
Wash	142.5-152.0			
9	152.0-161.5	9.5	3.0	32.0
Wash	161.5-171.0			
10	171.0-180.5	9.5	9.5	100.0
Wash	180.5-190.0			
11	190.0-199.5	9.5	6.4	67.0
Wash	199.5-209.0			
12	209.0-218.5	9.5	5.8	61.0
Wash	218.5-228.0			
13	228.0-237.5	9.5	3.0	32.0
Wash	237.5-247.0			
14	247.0-256.5	9.5	7.0	74.0
Wash	256.5-266.0			
15	266.0-275.5	9.5	1.4	15.0
Wash	275.5-351.5			
16	351.5-361.0	9.5	0.6	6.0
Wash	361.0-456.0			
17	456.0-465.5	9.5	2.4	25.0
Wash	465.5-528.5	Drilling rate decrease at 528m		
18	528.5-531.5	3.0	0.8	27.0
Total	531.5	164.5	91.0	55.0

[a]See Figure 5 for graph of drilling rate and lithologies.

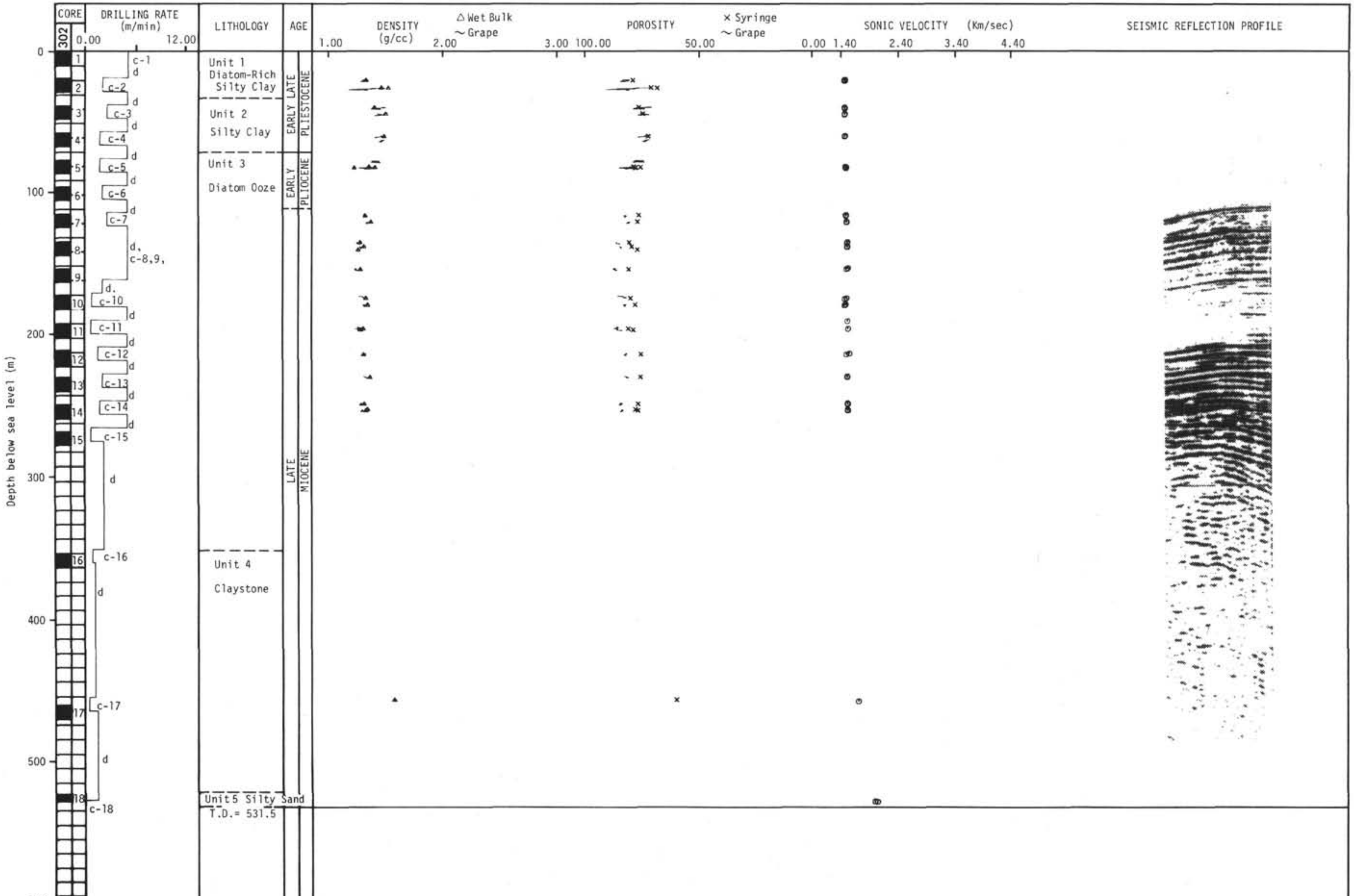

Figure 5. *Hole summary diagram, Site 302.*

LITHOLOGY

Hole 302 was drilled to a subbottom depth of 531.5 meters. The lithologic section is divided into five units (Table 2 and Figure 5).

Unit 1

Unit 1 is a greenish-gray diatomaceous-rich silty clay with thin layers of greenish-black micarb ooze, clayey diatomaceous ooze, and white ash. Pumice fragments and two mudstone fragments were also found. The base of Unit 1 was established at 33 meters in the uncored interval between Cores 2 and 3. Bedding is well defined with the darker micarb and lighter ash layers; however, the bedding is generally intensely deformed by drilling. The detrital component is composed primarily of plagioclase (7%-15%), quartz (3%-12%), and a trace of volcanic glass. Pyrite (3%-5%), micarb (2%-5%), and clay minerals (30%-35%) are ubiquitous authigenic components. The organic carbon content is quite high (0.7%—one sample). Diatoms and foraminifera are the major fossil groups, although radiolarians, sponge spicules, and silicoflagellates are also present. The unit is late Pleistocene in age.

Unit 2

This unit is a dark greenish-gray silty clay with color variations of olive-gray, medium gray, and brownish-black. The latter occurs in zones or layers where the micarb component increases. The base of Unit 2 was established in the uncored interval between Cores 4 and 5 (71 m). The presumed thickness for Unit 2 is 38 meters. Clay minerals (30%-45%) are the major component, with feldspar (15%), heavy minerals (5%) including amphibole, chlorite, and mica as the detrital components. Minor amounts (5%) of pyrite and micarb are present. Diatoms are the sole fossil component often concentrated in thin layers as diatomaceous oozes. The unit ranges in age from early to late Pleistocene.

Unit 3

Unit 3 is a diatom ooze varying in color from greenish-gray to olive-gray, with darker colors generally more abundant in micarb. The detrital component is small generally being less than 25%, and is composed predominantly of quartz, feldspar, and mica. Pyrite is ubiquitous in amounts up to 10%. Clay minerals are present in amounts up to 30%. The unit becomes more lithified with depth, and occasional chert zones occur. Abundant diatoms, Radiolaria, sponge spicules, and silicoflagellates give an age of late Miocene to early Pliocene. The Unit 3-4 boundary has been established at 352 meters (Core 16, Section 1); however; a significant drop in the drilling rate did occur at 270 meters (Figure 5). Black, dark gray chert was recovered at 275.5 meters.

Unit 4

An olive-gray to olive-black, mildly bioturbated occasional zeolite-bearing clay, but dominantly a silty-rich clay, and claystone. Clay minerals (45%-65%) are the major component, with detrital quartz (1%), feldspar (1%-10%), and mica also present. Diagenetic components include pyrite (2%-7%), micarb (1%-7%), cristobalite and tridymite. Diatoms and Radiolaria indicate a late Miocene age. The unit may be over 177 meters thick if it occurs in the noncored intervals between Cores 16, 17, and 18.

Unit 5

The last core (Core 18) penetrated the top of a volcanogenic unit which starts as a dark greenish-gray silty sand with minor gravel sizes, passing rapidly downwards into a grayish-green tuff. The tuff is composed almost solely of volcanogenic fragments of devitrified glass and feldspar, with essentially no heavy minerals. Pyrite in amounts up to 10% is present as a diagenetic mineral. Tabular fragments of tuff show an imbricate structure. A late Miocene age is suggested.

TABLE 2
Unit Descriptions, Depths, Thicknesses, and Ages, Site 302

	Unit and Description	Depth (m)	Thickness (m)	Age
1	Greenish-gray clayey diatomaceous ooze with greenish-black layers of micarb ooze, and thin layers and fragments of ash	0-33	>28.5–<33.0	Late Pleistocene
2	Dark greenish, to medium to olive-gray zeolite clay with local brownish-black zones rich in micarb	33-71	>33–<71.0	Early to Late (?) Pleistocene
3	Variegated greenish to dark greenish-gray diatomaceous ooze with local dark patches of micarb ooze	71-352.5	≅281.5	Late Miocene to Early Pliocene
4	Olive-gray to olive-black zeolite-rich clay and claystone with local zones of micarb chalk	352.5-529.4	≅177(?)	Late Miocene
5	Grayish-green volcanic silty sand and tuff	529.4-531.5	>2.1	?

Lithologic Interpretations

The geologic history begins with a period of pre-late Miocene volcanic activity. Seismic profiles indicate that this activity may have deposited thick volcanogenic piles of sediments in this area. The subsequent history is one of continuous pelagic sedimentation, in regions which were sufficiently cold so that calcareous fossils are either absent or present only in small amounts. It is possible that the carbonate compensation depth (CCD) has been abnormally shallow. Variations in the generally uniform pelagic sedimentation are seen during the early Pliocene to late Miocene to the latter part of the Pleistocene when diatoms are especially abundant. The age of the basement is somewhat ambiguous although displaced nannofossils of Oligocene age (in Core 18) would suggest a minimum age.

PHYSICAL PROPERTIES

Density, Porosity, and Water Content

The upper two lithologic units (Cores 1 to 4) show an increase in density (1.33-1.56 g/cc) followed by a decrease which, in Unit 4, (below Core 5) becomes rather constant (1.34-1.47 g/cc). The analog records below Core 5 show very even, slightly undulating, curves (Figure 5). It also is obvious that the diatom oozes and diatomites have a consistently low bulk density, with any variations being primarily a function of clay content.

Two sample pieces from Core 17, Section 2 were measured outside the liner. They had values of 1.55 and 1.51 g/cc for density and 72% and 75% for porosity. By using the actual diameters (2.35 and 2.37 in., respectively), values of 1.37 g/cc and 75% are obtained for density and porosity. This places these sediments in line with those of Unit 4.

The density measurements indicate that no consolidation of any noticeable effect takes place with depth in so far as having an effect on density. The ship's laboratory-derived densities are in general lower than those obtained from the GRAPE analog records. Water content follows the same basic tendencies as do the density and porosity values. Only Core 17 presents an exception.

Water content, density, and porosity values show that the sediments from Cores 1 through 4 belong to a single grouping, with a possible subdivision between Cores 2 and 3. Core 5 represents a transition to a lower group represented by Cores 7 through 14. Although Core 17 has a lower water content than any of the other cores, the bulk density and porosity do not change with depth.

Vane Shear

Vane-shear measurements were taken to a depth of 361 meters. The data indicate two trends, one from 0 to 85 meters and one from 120 to 361 meters. The high relative shear strength of the sediments from the upper interval may be a function of the high clay content.

The lithology through the 120-361 meter interval is predominantly a diatom ooze which shows the steepest shear strength-depth curve of any sedimentary deposit encountered on Leg 31. Further discussion of the shear-strength measurements at Site 302 will be found in Bouma and Moore (this volume).

Sonic Velocity

All sonic-velocity values are summarized in Figure 5 and in Table 3. The sonic-velocity values systematically increase to a depth of 250 meters. A value of 1.71 km/sec was measured from consolidated sediment at 458.6 meters.

At a depth of 529 meters, the sonic velocities suddenly increase from 1.71 km/sec (consolidated sediment at 458.6 m), to a value of 1.99 km/sec for the hard piece of micarb found in Core 18, and value of 2.04 km/sec for the green brecciated tuff. This velocity change corresponds well to the deepest reflector seen on the seismic record.

Thermal Conductivity

All values are summarized in Table 4 and graphically displayed in Figure 6. While no obvious trend can be seen in the thermal-conductivity values, there does appear a minor decrease of values with increasing depth.

TABLE 3
Sonic-Velocity Measurements,
Site 302

Sample (Interval in cm)	Depth in Hole (m)	Velocity (km/sec)
2-2, 111	21.61	1.483
2-2, 90	21.40	1.471
2-2, 38	20.88	1.480
3-2, 115	40.65	1.485
3-2, 75	40.25	1.481
3-2, 35	39.85	1.480
3-5, 108	45.08	1.479
3-5, 55	44.55	1.483
4-3, 102	61.02	1.479
4-3, 52	60.52	1.491
5-5, 26	82.26	1.494
5-5, 46	82.46	1.504
5-5, 71	82.71	1.512
5-5, 98	82.98	1.506
5-5, 125	83.25	1.513
7-2, 35	115.85	1.510
7-2, 86	116.36	1.498
7-5, 50	120.50	1.509
7-5, 100	121.00	1.517
8-2, 50	135.00	1.528
8-2, 100	135.50	1.523
8-4, 50	138.00	1.526
8-4, 100	138.50	1.528
9-2, 50	154.00	1.538
9-2, 100	154.50	1.508
10-3, 50	174.50	1.511
10-3, 100	175.00	1.477
10-6, 50	179.00	1.498
10-6, 100	179.50	1.478
11-5, 50	196.50	1.540
11-1, 107	191.07	1.529
12-4, 50	214.00	1.566
12-4, 100	214.50	1.511
13-2, 50	230.00	1.522
13-2, 100	230.50	1.524
14-2, 50	249.00	1.527
14-2, 100	249.50	1.533
14-5, 50	253.50	1.529
14-5, 100	254.00	1.539
17-2, 107	458.57	1.707
18-1, 132	529.82	2.035
18-1, 108	529.58	1.991

TABLE 4
Thermal-Conductivity Measurement at Site 302

Sample (Interval in cm)	Depth Hole (m)	Thermal Conductivity (10^{-3}cal/cm sec°C) Needle Probe	Average	From Water Content
2-2, 23	22	1.54	1.56	1.77 ±0.10
2-2, 74	22	1.52		
2-2, 116	23	1.63		
3-2, 35	42	1.90	1.78	
3-2, 75	43	1.73		1.88 ±0.11
3-2, 115	43	1.72		
3-5, 35	44	1.79	1.83	
3-5, 75	45	1.81		1.99 ±0.11
3-5, 115	45	1.88		
4-3, 35	60	1.70	1.70	
4-3, 75	61	1.69		2.03 ±0.11
4-3, 110	61	1.72		
5-2, 35	78	1.69	1.70	
5-2, 75	78	1.79		
5-2, 110	79	1.62		
7-2, 35	116	1.59	1.64	
7-2, 75	116	1.66		1.81 ±0.10
7-2, 110	117	1.67		
7-5, 35	120	1.61	1.64	
7-5, 75	121	1.66		1.84 ±0.10
7-5, 110	121	1.64		
8-2, 35	135	1.57	1.58	
8-2, 75	135	1.57		1.70 ±0.10
8-2, 110	136	1.61		
8-4, 35	142	1.70	1.68	
8-4, 75	143	1.66		1.74 ±0.10
8-4, 110	143	1.68		
9-2, 35	154	1.49		
9-2, 75	154	1.48	1.49	1.70 ±0.10
9-2, 110	155	1.49		
10-3, 40	174	1.68	1.71	1.75 ±0.10
10-3, 75	175	1.66		
10-3, 110	175	1.78		
10-6, 40	179	1.70	1.70	
10-6, 75	179	1.66		1.80 ±0.10
10-6, 110	180	1.74		
11-5, 40	196	1.59	1.61	
11-5, 75	197	1.60		1.73 ±0.10
11-5, 110	197	1.65		
12-4, 40	214	1.60	1.62	
12-4, 75	214	1.63		1.81 ±0.10
12-4, 100	215	1.64		
13-2, 40	230	1.55	1.60	
13-2, 75	230	1.57		1.85 ±0.10
13-2, 110	231	1.67		
14-2, 40	249	1.58	1.57	
14-2, 75	249	1.55		1.79 ±0.10
14-2, 110	250	1.59		
14-5, 40	253	1.61	1.63	
14-5, 75	254	1.63		1.80 ±0.10
14-5, 110	254	1.64		

GEOCHEMICAL MEASUREMENTS

Alkalinity

The average alkalinity of six samples from Site 302 is 13.13 meq/kg. Five of these values (Cores 2 to 14) are higher than the surface seawater reference value of 2.18 meq/kg. The highest values are found in Cores 5, 8, and 11 showing 16.23, 16.62, and 16.23 meq/kg, respectively. One core (Core 17, Section 1) shows a very significant low value of 2.15 (Table 5).

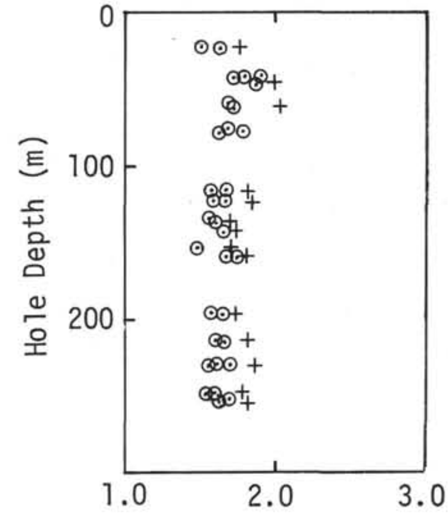

Figure 6. *Thermal conductivity (×10^{-3} cal/cm sec°C) versus depth for Site 302.*

pH

The average *p*H was below that of the seawater reference at the site (8.16 and 8.05). The five punch-in values averaged 7.44, while the six flow-through values averaged 7.42.

Salinity

Six salinity measurements averaged 32.5‰. A decrease in salinity occurs with increasing depth. All six values and their average were lower than the overlying seawater value of 34.1‰.

PALEONTOLOGIC SUMMARY

Introduction

Site 302 was located on the northern flank of the Yamato Rise and drilling penetrated a total of 531.5 meters of Pleistocene through Miocene(?) sediments. Diatoms are common to abundant in Core 1 through the upper part of Core 16 (0-353 m), with calcareous nannofossils marginally present through Core 17 (0-459 m). Planktonic foraminifera occurrences are limited to Cores 1 through 3 (0-40 m).

Diatoms again provide the principal biostratigraphic control at this site, and the sequence of zones encountered is similar to that established at Site 301. Silicoflagellates also occur within diatom-rich intervals. The general siliceous microfloral succession is quite similar to that of other high-latitude areas of the North Pacific, including the Bering Sea scrutinized during Leg 19.

The late Pleistocene/early Pleistocene boundary is placed between Core 2, Sections 4 and 5 (25 m), based on diatom and silicoflagellate zonations. However,

TABLE 5
Summary of Shipboard Geochemical Data, Site 302

Sample (Interval in cm)	Depth Below Sea Floor (m)	pH Punch-in	pH Flow-through	Alkalinity (meq/kg)	Salinity (°/°°)	Lithologic Units
Surface sea water reference		9.16	8.05	2.18	34.1	
2-5, 144-150	26.5	7.24	7.33	12.90	33.3	Unit 1
5-4, 144-150	82.0	7.44	7.58	16.23	33.3	
8-5, 144-150	140.5	7.40	7.27	16.62	33.0	Unit 3
11-4, 144-150	196.0	7.75	7.55	16.23	32.7	
14-4, 144-150	253.0	7.38	7.38	14.66	32.2	
17-1, 144-150	457.5	–	7.41	2.15	30.8	Unit 4
Average		7.44	7.42	13.13	32.5	

calcareous nannofossil zonation indicates the late Pleistocene occurs to Core 3, Section 4 (61 m), based on the limits of the *Gephyrocapsa oceanica* Zone.

The precise position of the Pliocene/Pleistocene boundary is difficult to determine due to sparse diatoms in the critical interval. This is similar to the situation noted at Site 301. Sparse diatom zonation indicates the boundary likely occurs somewhere in the interval between the base of Core 3 through Core 4 (45-66.5 m). Marginal calcareous nannofossil floras suggest the boundary may occur between Cores 4 and 5 (66.5-76 m).

Core 5 (76-85.5 m) contains both calcareous and siliceous Pliocene microfossils, but zonation suggests a disconformity may be present with this core. Sections 1 to 3 of Core 5 (76-80 m) contains a portion of the established late Pliocene diatom zones, whereas Sections 4 through 6 (80-85.5 m) contain early Pliocene diatoms with the apparent absence of a significant portion of the late Pliocene.

Cores 8 through 16 (142.5-352.5 m) contain diatoms traditionally assigned to the late Miocene on Honshu by Japanese biostratigraphers. However, recent analyses by Burckle (1971) and Schrader (1973) place these same floras in the early Pliocene, and this revised view is followed in this report.

Calcareous Nannofossils

Once again the cold-water conditions characteristic of this part of the Sea of Japan are reflected in the sparse nannofossil recovery.

Cores 1 through 3-4 were found to contain an assemblage with *Gephyrocapsa oceanica* which belongs in the late Pleistocene *G. oceanica* Zone. Core 4 contains rare specimens of *Gephyrocapsa doronicoides*, which may place it in the early Pleistocene *G. doronicoides* Zone. Core 5 contains a few specimens of *Reticulofenestra pseudoumbilica* with heavy overgrowths of calcite, which may be indigenous to this early Pliocene sample. Core 10 contains reworked specimens of the late Oligocene species, *Cyclicargolithus abisectus* and *Sphenolithus ciperoensis*. Of the remaining samples, only Cores 11, 14, 16, and 17 contain nannofossils; nearly all of which have been reworked into the younger sediments.

Foraminifera

Planktonic foraminifera were found only within Cores 1 through 3 and represent a late Pleistocene subarctic to cool temperate biofacies dominated by "*Globigerina*" *pachyderma*. Rare specimens of benthonic species also occur within these same sediments, and isolated specimens of arenaceous benthonic species are present in older sediments otherwise barren of foraminifera.

Radiolarians and Silicoflagellates

Site 302 proved the most productive of four sites drilled in the Sea of Japan in terms of radiolarian and silicoflagellate abundance.

Radiolarians found in Cores 1 and 2 are similar to those observed in Pleistocene sediments from the Bering Sea sampled during Leg 19. Radiolarians are rare or absent in Core 3, whereas *Druppatractus acquilonius* and *Thecosphaera japonica* are present in Core 4. The youngest occurrences of *Anthocorys* (?) *akitaensis* and *Thecosphaera akitaensis* were noted in Core 5, Section 3 with the late-early Pliocene boundary drawn between Core 5, Sections 3 and 5 on the basis of diatom zonation. *Theocyrtis redondoensis* was noted in Core 12 through Core 14, Section 3. Radiolarians are absent in sediments below Core 16.

The silicoflagellate *Distephanus crux* var. *stauracanthus* was recorded in Core 1. The absence of *Distephanus octangulatus* within this same core seems to suggest that the topmost part of the Pleistocene sediments were not sampled at this site. The presence of *Dictyocha subarctios* indicates the age of Core 2, Section 5 is approximately at the level of the Brunhes normal-Matuyama magnetic boundary. A sharp decline in silicoflagellate abundance is observed in Cores 3 and 4. Because the extinction of *Ammodochium rectangulare* occurs near the Plio-Pleistocene boundary, while that of *Ebriopsis antiqua* (spineless form) is within the Pliocene, the joint occurrence of these two taxa in Core 5 suggests that at least a portion of upper Pliocene sediments was not recovered. The top of the *Distephanus quinquangellus* Zone is drawn between Cores 7 and 8. The highest occurrence of *Mesocena elliptica* in Core 9 may provide another possible significant datum in Core 15 where, for the first time during this cruise, unmistakable specimens of *Mesocena circulus* var. *apiculata* were recovered. Silicoflagellates are completely absent from sediments below Core 16.

Diatoms

Pleistocene species occur throughout Core 1 to Core 3, Section 1. The boundary between the early and late

Pleistocene is placed between Core 2, Sections 4 and 5. Samples from near the Plio-Pleistocene boundary, Core 3, Section 5 through Core 4, contain only very rare, poorly preserved specimens. Therefore, the Plio-Pleistocene boundary cannot be defined from this site. Diatoms in Core 5, Section 4 through Core 8, Section 2 are considered early Pliocene in age.

Core 8, Section 5 through Core 16, Section 1 contain late Miocene (?) (possibly early Pliocene) diatom assemblages, previously described for Site 301. These assemblages are characterized by *Thalassiosira nativa* in Cores 10 through 16, *Coscinodiscus temperi*, *Thalassiosira manifesta*, and *Gomiothecium tenne* in Cores 12 through 16. *Cosmiodisus insigms* occurs in Samples 14, CC and 15, CC, and *Ronxia californica* occurs in Cores 16 and 17.

SUMMARY AND INTERPRETATIONS

Summary

Drilling at Site 302 penetrated 531.5 meters into the northern flank of Yamato Rise. However, the lower 275 meters of this sequence was sampled in only three widely spaced cores (Cores 16, 17, and 18) due to the necessity of pulling out of this hole earlier than scheduled because of a medical emergency onboard.

The section sampled at Site 302 can be conveniently broken into five lithologic units. Unit 1 consists of 33 meters of diatomaceous-rich silty clay with micarb ooze, clayey diatomaceous ooze, and ash of late Pleistocene age. Unit 2 extends from 33 to 71 meters and consists of an upper Pliocene-lower Pleistocene zeolitic clay. Unit 3 occurs from 71 to 352.5 meters and consists of diatomaceous ooze of late Pliocene through earliest Pliocene age. A single core (17) at 456 to 465.5 meters encountered a late Miocene (?) zeolite-rich clay and claystone with micarb chalk assigned to Unit 4. Hole 302 terminated in a grayish-green Miocene (?) silty sand and tuff cored from 529.4 to 531.5 meters (Core 18) and was assigned to Unit 5.

Correlation of the lithologic units with the acoustic units at Site 302 suggests that the uppermost reflectors correspond to Units 1 and 2, with the ubiquitous transparent acoustic unit equivalent to the diatomaceous sediments of Unit 3. The initial occurrence of harder clays at 270 meters was marked by an abrupt drop in drilling rate (Figure 5), and appears to correlate with the top of the deeper set of acoustic reflectors with opaque basement correlative with the top of the Miocene (?) green tuffs and sands.

Definitive faunal control is again provided by diatoms at Site 302 as at other sites in the Sea of Japan. However, common to abundant diatoms are only present in the Pliocene and Pleistocene sediments of Cores 1 through 16 (0-353 m), with the base of Hole 302 assigned a questionable Miocene age.[2] Diatom zonation indicates that there is a significant disconformity present between 80 and 85.5 meters where a portion of the late Pliocene appears to be missing. The Pliocene-Pleistocene boundary is thought to occur within the 45 to 66.5 meter interval. Silicoflagellates and radiolarians also occur in significant abundances at this site, but sparse planktonic foraminifera are restricted to late Pleistocene sediments. This is probably due to the depth of water at Site 302 (2399 m), which is below the local CCD according to Ujiié and Ichikura (1973). Calcareous nannofossils are present in marginal abundance to Core 17 and include reworked late Oligocene species in Core 10. All microfossils reflect cool temperate to arctic surface temperatures, with siliceous assemblages similar to those found at other DSDP sites in the North Pacific region.

Interpretation

The relatively uniform pelagic nature of the major portion of the column sampled on the Yamato Rise argues for a rather simple late Neogene sedimentary history for this major bathymetric feature. Unfortunately, the fact that Hole 302 did not penetrate to the assumed late Paleozoic core does not allow a final statement to be made regarding the earliest sedimentary events on the rise with their attendant implications for evolution of the Japan Sea. Nevertheless, the later Neogene history of the rise is well displayed in the cores recovered and appears to fit rather well with known Neogene sequences elsewhere in this region (Asano et al., 1969; Kim, 1968).

The unfossiliferous green tuff encountered at the base of Hole 302 may well correlate with the interval of volcanism marked by early Miocene green tuffs in northern Honshu. These latter rocks underlay a series of Neogene nonmarine (Daijima Formation) and marine rocks (Nishikurosawa Formation) thought to represent the early marginal history of the Japan Sea by many workers (Kaseno, 1971; Ingle, this volume). Direct correlation of the basal green tuffs sampled at Site 302 on Yamato Rise thus suggests these beds are also early Miocene in age, which appears to fit with their stratigraphic position within the rise sequence. Assuming the tuffs are a minimum of 15 m.y. old (latest early Miocene) yields an estimated rate of sedimentation of about 25 m/m.y. for the overlying unfossiliferous portion of Unit 4. This is well within reason for the lithology and locality concerned, especially in view of the estimated rate of 22 to 28 m/m.y. for Unit 2 (Figure 7). In fact, estimated sedimentation rates at this site dictate that the base of the section can be no older than early Miocene. Unfortunately, a lack of in situ fossils in these older sediments does not shed any light on the nature or rate of subsidence of the rise. However, it is tempting to regard the green tuffs and sands as shallow marine or nonmarine deposits, thus portending a history of subsidence for the rise similar to that established for southern, eastern, and northern margins of the sea (Ingle, this volume).

Late Miocene diatom-rich sediments appear at 350 meters and accumulated at an approximate rate of 80 m/m.y. at least into early Pliocene time (Figure 7). This rapid rate of accumulation of biogenous debris attests to

[2]Spore and pollen from Core 18 were scanned by W.R. Evitt of Stanford University and thought to exhibit a Miocene aspect.

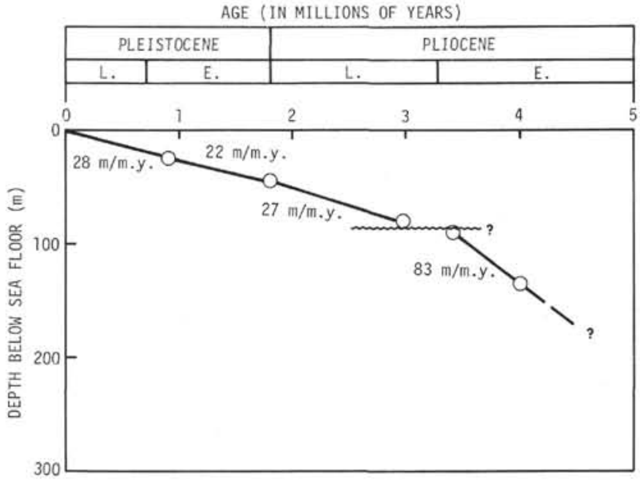

Figure 7. *Estimated rate of sedimentation at Site 302 based upon correlation of diatom zonation with the radiometric and paleometric time scales (Koizumi, this volume). Disconformity at 80 meters represents an interval of missing late Pliocene assemblages.*

the exaggerated planktonic productivity in the Japan Sea during the Late Miocene. Increased productivity during this particular interval is very likely a function of the late Miocene period of polar refrigeration discussed previously with Site 301 (Chapter 12, this volume).

Indeed, the late Miocene-Pleistocene history of sedimentation on the Yamato Rise appears to be largely a function of climatically induced variations in the rate of productivity in the overlying water mass with a single significant structural or sedimentologic event in the mid-Pliocene as marked by the disconformity at 80 meters (Figure 7).

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APPENDIX A
Summary of X-Ray, Grain Size, and Carbon-Carbonate Results, Site 302

Section	Sample Depth Below Sea Floor (m)	Lithology	Age	Bulk Sample Major Constituent			2-20µm Fraction Major Constituent			<2µm Fraction Major Constituent			Grain Size			Classification	Carbon Carbonate			Comments
				1	2	3	1	2	3	1	2	3	Sand (%)	Silt (%)	Clay (%)		Total (%)	Organic (%)	$CaCO_3$ (%)	
302-2-5	26.3	Unit 1 Clayey Diatom ooze	Late Pleistocene	Quar.	Mica	Plag.	Quar.	Plag.	Mica	Mica	Quar.	Plag.	4.6	38.2	57.2	Silty Clay	1.3	0.7	6	Pyri. in bulk (1.1%) Kaol. in <2µm (3.3%)
302-3-1	38.7	Unit 2 Zeolite Silty clay or Zeolite-rich Silty clay	Early to late (?) Pleistocene	Quar.	Mica	Plag.	Quar.	Plag.	Mica	Mica	Quar.	Mont.	0.1	34.2	65.7	Silty Clay	0.5	0.4	1	Pyri. in 2-20µm, <2µm (1.0, 3.4%)
302-4-4	62.9												0.4	36.1	63.5	Silty Clay	0.6	0.5	1	
302-5-4	82.0	Unit 3 Diatom ooze	Late Miocene to early Pliocene	Quar.	Mica	Plag.	Quar.	Plag.	Mica	Mica	Quar.	Mont.	0.3	32.2	67.5	Silty Clay	–	–	–	Pyri. in bulk, 2-20µm (1.9, 1.2%)
302-7-5	120.8-120.9			Quar.	Mica	Plag.	Quar.	Plag.	Mica	Mica	Mont.	Quar.	0.7	46.6	52.7	Silty Clay	0.7	0.7	1	Kaol. in <2µm (3.0%)
302-8-6	141.9-142.0												13.7	46.7	39.5	Clayey Silt	0.5	0.4	1	
302-10-1	171.6			Quar.	Mica	Plag.	Quar.	Plag.	Mica	Mont.	Mica	Quar.	1.8	30.8	67.4	Silty Clay	0.7	0.6	0	Pyri. in bulk, 2-20µm (4.9, 2.7%)
302-11-3	194.4																0.6	0.5	0	Kaol. in <2µm (1.5%)
302-15-1	266.8-266.9			Quar.	Mont.	Plag.	Quar.	Plag.	Mica	Mont.	Quar.	Mica.	1.7	29.1	69.3	Silty Clay	0.9	0.7	1	Pyri. in bulk 2-20µm & <2µm (11-2, 11-4, 4-3)
302-17-1	456.1-456.2	Unit 4 Zeolite-rich clay, Silt-rich clay and Claystone	Late Miocene	Cris.	Quar.	Mont.	Quar.	Cris.	Mica	Cris.	Mont.	Mica.	0.2	18.0	81.8	Clay	0.9	0.7	2	Pyri. in bulk, 2-20µm, <2µm (4.2, 5.6 (0.9), Trid. in bulk, 2-20µm, <2µm (1.4, 1.2, 4.7%)

Note: Complete results X-Ray, Site 302, will be found in Part V, Appendix I, X-ray mineralogical legend will be found in Appendix A, Chapter 2.

Site 302 Hole Core 1 Cored Interval: 0.0-9.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE	G. pachyderma-G. umbilicata; Gephyrocapsa oceanica (S); Distephanus octangulatus (S); Rhizosolenia curvirostris (D)	Cg	Rm	Cm	Fm Fg	Core Catcher				CC	5GY 4/1

Unit 1. Trace amount recovered in core catcher, dark greenish gray (5GY 4/1).

DIATOM-RICH SILTY CLAY
Smear: CC

Texture	Composition
60% Clay	30% Clay minerals
40% Silt	20% Diatoms
	15% Feldspar
	12% Quartz
	7% Sponge spicules
	5% Pyrite
	5% Micarb
	3% Foraminifera
	3% Silicoflagellates
	Tr% Volcanic glass

Explanatory notes in chapter 1

Site 302 Hole Core 2 Cored Interval: 19.0-28.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE PLEISTOCENE	Dictyocha subarctios (S)			Ag	Cm Fg	1	0.5, 1.0	VOID			5GY 4/1 → 5GY 2/1
			B			2				90 *	
				Ag	Cm Fg	3					
			B		Cm	4					5GY 4/1 → 5GY 2/1
				Ag	Rg	5		GEOCHEM SAMPLE			
	G. pachyderma-G. umbilicata; Rhizosolenia curvirostris (D)		B			6					5GY 4/1, 5GY 2/1, 5Y 4/4
		Cg	Rm	Ag	Ag Cm	Core Catcher				CC *	5GY 4/1

Colors: greenish gray (5GY 4/1) and greenish black (5GY 4/1); deformation-drilling breccia to intense deformation; some pumice fragments and mudstone erratics.

DIATOM-RICH SILTY CLAY

CLAYEY DIATOMACEOUS OOZE (Minor Lith)
Smear: CC

Texture	Composition
80% Clay	40% Diatoms
20% Silt	35% Clay minerals
	10% Sponge spicules
	7% Feldspar
	3% Quartz
	3% Pyrite
	2% Micarb

MICARB OOZE (Minor Lith)
Smear: 2-90

Texture	Composition
80% Clay	40% Micarb
20% Silt	30% Clay minerals
	10% Feldspar
	10% Diatoms
	5% Pyrite
	3% Heavy minerals
	2% Radiolarians

Grain Size 5-130
4.6, 38.2, 57.2

Carbon Carbonate 5-130
1.3, 0.7, 6

X-ray 5-130 (Bulk)
41.2% Quar
28.7% Mica
18.8% Plag
4.0% Chlo
3.2% Mont
2.9% Calc
1.1% Pyri

Explanatory notes in chapter 1

Site 302 Hole Core 3 Cored Interval: 38.0-47.5 m

AGE: LATE PLEISTOCENE

ZONE: Gephyrocapsa oceanica; Dictyocha subarctios (S); Rhizosolenia curvirostris (D)

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO., DIATOMS): Rp, Rm, Cm; Rp; B; Cm; B, B; Am; B, B, Fp; Rm, Fm; B, Rp, Fm, B, Cm

SECTION: 1, 2, 3, 4, 5, 6, Core Catcher — METERS: 0.5, 1.0 — LITHO. SAMPLE: 70

LITHOLOGIC DESCRIPTION

Unit 2. Colors: dark greenish gray (5GY 4/1), brownish black (5Y 2/1); pyritized worm burrows; intense drilling deformation.

5GY 4/1
5Y 2/1

SILTY CLAY
Smear: 1-70

Texture	Composition
65.7% Clay	47% Clay minerals
34.2% Silt	25% Quartz
0.1% Sand	15% Feldspar
	5% Heavy minerals
	5% Pyrite
	2% Plant debris
	1% Micarb
	Tr% Zeolite

5GY 4/1

5Y 2/1 MICARB CLAY (Minor Lith)

Grain Size 1-69
0.1, 34.2, 65.7

Carbon Carbonate 1-70
0.5, 0.4, 1

5Y 2/1

X-ray 1-71 (Bulk)
32.3% Quar
29.2% Mica
18.6% Plag
11.4% Mont
4.6% K-Fe
3.9% Chlo

5GY 4/1

5GY 4/1
5Y 2/1
5Y 2/1
5GY 4/1
5GY 4/1
5Y 3/2
5GY 4/1

Explanatory notes in chapter 1

Site 302 Hole Core 4 Cored Interval: 57.0-66.5 m

AGE: EARLY PLEISTOCENE

ZONE: Gephyrocapsa doronocoides (?); Actinocyclus oculatus (D)

FOSSIL CHARACTER (FORAMS, NANNOS, RADS, SILICO., DIATOMS): Rp, B, Fp; Rp; B, B, Fp; B; Fm, Rm, Fp; Fm, B, Cm, Rm, Fp

SECTION: 1, 2, 3, 4, 5, Core Catcher — METERS: 0.5, 1.0 — LITHO. SAMPLE: 148 *

LITHOLOGIC DESCRIPTION

Colors: medium gray (N5), olive gray (5Y 3/2); deformation, drilling breccia to intense.

SILTY CLAY
Smear: 4-148

Texture	Composition
64% Clay	43% Clay minerals
36% Silt	15% Quartz
	15% Feldspar
	5% Plant debris
	5% Diatoms
	5% Pyrite
	5% Mica
	1% Zeolite
	1% Micarb

N5 Grain Size 4-144
0.4, 36.1, 63.5

5Y 3/2 Carbon Carbonate 4-143
0.6, 0.5, 1

5GY 4/1

Explanatory notes in chapter 1

Site 302 Hole Core 5 Cored Interval: 76.0-85.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	G. inflata praeinflata; Reticulofenestra pseudoumbilica; Ebriopsis antiqua - cannopilus hemisphaericus (S); Denticula seminde-D. kamtschatica (D)			Fm	Fm	1	0.5, 1.0	VOID				Unit 5. Colors: varigated greenish gray (5GY 6/1) to dark greenish gray (5GY 4/1) with dark = higher micarb content, some dark gray (N3), medium gray (N5) zones; drilling breccia to intense deformation; moderate amount pyritized burrows (3-95).
			B			2					5GY 6/1 ↕ 5GY 4/1	DIATOM OOZE Smears: 3-62, 4-100 Texture: 68% Clay, 32% Silt Composition: 70-75% Diatoms, 5-10% Feldspar, 5-10% Clay minerals, 4- 9% Quartz, 5% Pyrite, 5% Micarb, 1% Zeolite Grain Size 4-147: 0.3, 32.2, 67.5
				Fm	Cm	3				* 62	5GY 6/1 ↕ 5GY 4/1	X-ray 4-147 (Bulk): 37.6% Quar, 28.4% Mica, 17.3% Plag, 6.3% Mont, 4.4% Chlo, 4.1% K-Fe, 1.9% Pyri
			B			4		GEOCHEM SAMPLE		* 100	5GY 6/1 ↕ 5GY 4/1	
				Cm	Am, Ag	5					N3 to N5; 5Y 4/4; N3-N4	
		Rm	Rp	Fm	Ca, —Ag—	Core Catcher					5G 4/1	

Explanatory notes in chapter 1

Site 302 Hole Core 6 Cored Interval: 95.0-104.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
EARLY PLIOCENE	Ebriopsis antiqua - cannopilus hemisphaericus (S); Denticula seminde-D. kamtschatica (D)	BF Rg	B	Fm	Fm —Ag—	Core Catcher					

Explanatory notes in chapter 1

Site 302 Hole Core 7 Cored Interval: 114.0-123.5 m

AGE: LATE MIOCENE

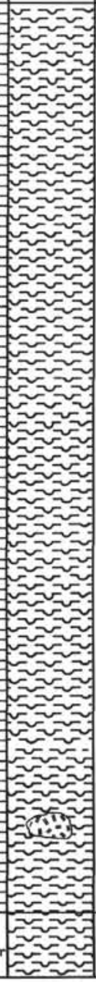
ZONE: Ammodochium rectangulare - cannopilus hemisphaericus (S); Denticula kamtschatica (D)

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Fm Rm; B; Rm Fm; Cg Rm; B; BF Rg, B, Fm, Fm, Ag

SECTION: 1, 2, 3, 4, 5, 6, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY:



LITHO. SAMPLE: 95 *; CC *

Colors at right of column: N8, 5GY 4/1, 10Y 4/2

LITHOLOGIC DESCRIPTION

Colors: dark greenish gray (5GY 4/1) gray olive (10Y 4/2); moderate drilling deformation.

DIATOM OOZE
Smears: 1-95, CC

Texture	Composition
60% Clay	60% Diatoms
40% Silt	10% Clay minerals
	10% Radiolarians
	10% Sponge spicules
	3% Silicoflagellates
	3% Pyrite
	3% Feldspar
	1% Quartz

VOLCANIC ASH (Minor Lith)

Grain Size 5-83
0.7, 46.6, 52.7

Carbon Carbonate 5-85
0.7, 0.7, 1

X-ray 5-86 (Bulk)
36.4% Quar
29.2% Mica
17.1% Plag
9.2% Mont
4.2% Chlo
3.9% K-Fe

5GY 4/1

Explanatory notes in chapter 1

Site 302 Hole Core 8 Cored Interval: 133.0-142.5 m

AGE: LATE MIOCENE

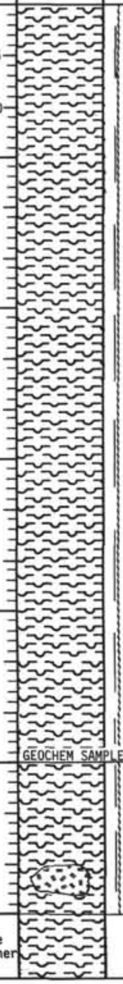
ZONE: Distephanus quinquangellus (S); Denticula kamtschatica (D)

FOSSIL CHARACTER (FORAMS / NANNOS / RADS / SILICO. DIATOMS): Fm Am; B; Fm Am; Fm Am; B; B, B, Fm, Fm, Ag

SECTION: 1, 2, 3, 4, 5, 6, Core Catcher

METERS: 0.5, 1.0

LITHOLOGY:



LITHO. SAMPLE: 130 *; 145 *; CC *

Colors at right of column: 10Y 4/2, 5Y 4/1, N4, 10Y 4/2

LITHOLOGIC DESCRIPTION

Colors: grayish olive (10Y 4/2), olive gray (5Y 4/1) with some medium dark gray (N4) and light olive brown (5Y 5/6); intense-moderate drilling deformation, firm; color streaking noted.

DIATOM OOZE
Smears: 5-130, 6-145, CC

Texture	Composition
46.7% Silt	56-74% Diatoms
39.5% Clay	10-20% Clay minerals
13.7% Sand	3- 7% Feldspar
	3% Pyrite
	2% Sponge spicules
	1- 3% Quartz
	Tr- 1% Micarb
	1% Radiolarians
	1% Silicoflagellates

VOLCANIC ASH (Minor Lith)

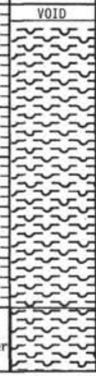
Grain Size 6-146
13.7, 46.7, 39.5

Carbon Carbonate 6-140
0.5, 0.4, 1

Explanatory notes in chapter 1

Site 302 Hole Core 9 Cored Interval: 152.0-161.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO.	DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Denticula kamtschatica (D)		B	Rm		Cm	1	0.5, 1.0	VOID			
							2				141 *	
		BF Rg	B	Cm	Ag	Cm	Core Catcher				CC *	



10Y 4/2
5Y 4/1
10Y 4/2

Colors: grayish olive (10Y 4/2), olive gray (5Y 4/1), with minor medium dark gray (N4); color streaking; breccia to intense drilling deformation, firm.

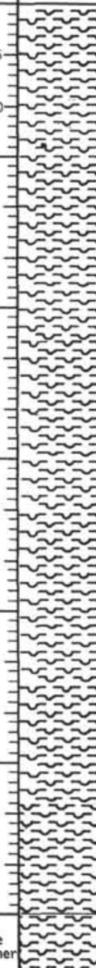
DIATOM OOZE
Smears: 2-141, CC

Texture	Composition
80-95% Clay	75-80% Diatoms
5-20% Silt	10-15% Clay minerals
	3-10% Feldspar
	2- 3% Micarb
	1- 3% Radiolarians
	1- 3% Pyrite
	1- 2% Quartz
	1% Mica
	Tr% Sponge spicules

Explanatory notes in chapter 1

Site 302 Hole Core 10 Cored Interval: 171.0-180.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO.	DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Denticula kamtschatica (D)			Fm		Am	1	0.5, 1.0			65 *	
			B				2					
				Rm		Am	3					
							4					
				Rm		Am						
			B				5					
							6					
		B	Rp	Ag	Ag	Ag	Core Catcher				CC *	



5GY 4/1
5GY 4/1

Color dark greenish gray (5GY 4/1), minor medium dark gray (N4) streaking; moderate-intense deformation, firm; isolated, hard lithified areas.

DIATOM OOZE
Smears: 1-65, CC

Texture	Composition
67% Clay	64-66% Diatoms
31% Silt	20% Clay minerals
2% Sand	4- 8% Feldspar
	2- 3% Pyrite
	2% Radiolarians
	1- 2% Quartz
	1% Sponge spicules
	1% Silicoflagellates
	Tr- 1% Micarb
	Tr- 1% Mica
	Tr% Glauconite

Grain Size 1-62
1.8, 30.8, 67.4

Carbon Carbonate 1-62
0.7, 0.6, 0

X-ray 1-63 (Bulk)
31.7% Quar
26.7% Mica
16.0% Plag
10.5% Mont
7.2% K-Fe
4.9% Pyri
3.0% Chlo

Explanatory notes in chapter 1

Site 302 Hole Core 11 Cored Interval: 190.0-199.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Distephanus quinquangellus (S) Denticula kamtschatica (D)					1	0.5, 1.0	VOID			5GY 4/1, 10Y 4/2
				Rm	Ag						
			B			2				96 *	
				Rm	Ag	3					10Y 4/2 with 5Y 5/2; 5Y 5/6
			B			4		GEOCHEM SAMPLE			10Y 4/2; 5GY 4/1; 5Y 5/2
				Rm	Ag	5				141 *	10Y 4/2 and 5GY 4/1; 5Y 5/2
		B	Rm	Cm	Ag	Core Catcher				CC *	10Y 4/2

Colors: dark green gray (5GY 4/1), grayish olive (10Y 4/2) with some medium dark gray (N4); bioturbation and isolated lithification; some light olive brown (5Y 5/6) zones; moderate drilling deformation, firm.

DIATOMACEOUS OOZE
Smears: 2-96, CC

Texture	Composition
90-93% Clay	64-80% Diatoms
7-10% Silt	10-20% Clay minerals
	1- 7% Feldspar
	1- 4% Mica
	1- 3% Quartz
	1- 2% Micronodules
	1% Micarb
	1% Radiolarians
	1% Sponge spicules
	1% Silicoflagellates

CLAYEY MICARB OOZE (Minor Lith)
Smear: 5-141

Texture	Composition
100% Clay	70% Micarb
	30% Clay minerals

Carbon Carbonate 3-140
0.6, 0.5, 0

Explanatory notes in chapter 1

Site 302 Hole Core 12 Cored Interval: 209.0-218.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Distephanus quinquangellus (S) Denticula kamtschatica (D)		B	Cm	Ag	1	0.5, 1.0				
						2				* 102	10Y 4/2; 5GY 4/1; 5Y 5/6
				Cm	Ag						
			B			3					
						4					
		B	B	Cm	Ag	Core Catcher				CC *	10Y 4/2

Colors: grayish olive (10Y 4/2) with dark greenish gray (5GY 4/1), some medium dark gray (N4) streaks, and light olive brown (5Y 5/6); intense drilling deformation, firm; some lithification.

DIATOM OOZE
Smear: 2-102, CC

Texture	Composition
90-93% Clay	67-70% Diatoms
7-10% Silt	15-20% Clay minerals
	6- 8% Feldspar
	2- 3% Micronodules
	1% Silicoflagellates
	1% Sponge spicules
	1% Radiolarians
	1% Micarb
	1% Zeolite
	1% Quartz
	Tr- 1% Mica

CLAYEY MICARB OOZE (Minor Lith)
(scattered)

Site 302 Hole Core 13 Cored Interval: 228.0-237.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Distephanus quinquangellus (S) Denticula kamtschatica (D)			Fm	Ag	1	0.5, 1.0	VOID		45 *	10Y 4/2; 5Y 4/4
			B								
						2					
		Rm	B	Cm	Ag	Core Catcher				CC *	10Y 4/2

Grayish olive (10Y 4/2), moderate olive brown (5Y 4/4); with intense drilling deformation, bioturbation, and lithification zones.

DIATOM OOZE
Smears: 1-45, CC

Texture	Composition
90-95% Clay	69-80% Diatoms
5-10% Silt	10-15% Clay minerals
	3- 8% Feldspar
	2- 3% Micronodules
	1% Quartz
	1% Mica
	1% Micarb
	1% Radiolarians
	1% Silicoflagellates

Explanatory notes in chapter 1

Site 302 Hole Core 14 Cored Interval: 247.0-256.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Distephanus quinquangellus (S) Denticula kamtschatica (D)	B	B, B, Rp	Cm, Cm, Cm, Cm	Ag, Ag, AG, Ag, Ag	1, 2, 3, 4, 5, Core Catcher	0.5, 1.0	VOID; GEOCHEM SAMPLE		CC *	5GY 4/1, 10Y 4/2; 5GY 4/1, 10Y 4/2; 5Y 4/4; 10Y 4/2

Colors: grayish olive (10Y 4/2), dark green gray (5GY 4/1), medium dark gray streaking (N4), and medium olive brown (5Y 4/4) at base of Section 5. Drilling breccia to intense drilling deformation; firm with lithification in areas.

DIATOM OOZE
Smear: CC

Texture	Composition
95% Clay	68% Diatoms
5% Silt	20% Clay minerals
	5% Micarb
	3% Feldspar
	2% Micronodules
	1% Quartz
	1% Radiolarians
	1% Sponge spicules

Explanatory notes in chapter 1

Site 302 Hole Core 15 Cored Interval: 266.0-275.5 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mesocena circulus var. apiculata (S) Denticula kamtschatica (D)	B	B, B	Fm, Cm	Ag, Ag, Ag	1, Core Catcher	0.5, 1.0	VOID		83 *, CC *	5Y 4/4; 5Y 4/4, N3

Colors: moderate olive brown (5Y 4/4), dark gray (N3); intense drilling deformation, firm; lithification to chert in core catcher.

DIATOM OOZE
Smears: 1-83, CC

Texture	Composition
69.3% Clay	53% Diatoms
29.1% Silt	25% Clay minerals
1.7% Sand	10% Quartz
	10% Felspar
	1% Radiolarians
	1% Carbonate

CHERT (Black-dark gray)

Grain Size 1-83
1.7, 29.1, 69.3

Carbon Carbonate 1-85
0.9, 0.7, 1

X-ray 1-86 (Bulk)
33.7% Quar
20.1% Mont
16.4% Plag
11.2% Pyri
8.0% Mica
7.2% K-Fe
3.3% Chlo

Explanatory notes in chapter 1

Site 302 Hole Core 16 Cored Interval: 351.5-361.0 m

AGE	ZONE	FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE	Mesocena circulus var. apiculata (S) Denticula kamtschatica (D)	B	B, B	Rm, B	Ag, Ag, B, Ag	1, Core Catcher	0.5, 1.0	VOID		98, 108, 114, 133	5GY 4/1, 10Y 4/2, 5YR 2/1, 5Y 3/2

Colors: dark green gray (5GY 4/1), grayish olive (10Y 4/2), brownish black (5YR 2/1), olive gray (5Y 3/2); intense drilling deformation - lithified; Unit 4 begins 352.5 meters.

DIATOM OOZE
Smear: 1-98

Texture	Composition
90% Clay	70% Diatoms
10% Silt	15% Clay minerals
	4% Micarb
	4% Feldspar
	3% Micronodules
	1% Quartz
	1% Mica
	1% Volcanic glass
	1% Radiolarians

CLAY
Smears: 1-108, 1-114, 1-133

Texture	Composition
90-98% Clay	80-88% Clay minerals
2-10% Silt	5- 7% Micronodules
	2- 5% Pyrite
	1- 7% Micarb
	1- 3% Zeolite
	1- 3% Feldspar
	1% Mica
	Tr- 1% Diatoms
	Tr- 1% Radiolarians

Explanatory notes in chapter 1

Site 302 Hole Core 17 Cored Interval: 456.0-465.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LATE MIOCENE			B	B	B	1	0.5, 1.0	VOID; GEOCHEM SAMPLE			
			B								
			Rp			2				73	5Y 3/2, 5Y 4/1, 5Y 2/1
		B	B	B	B, Rp	Core Catcher				CC	

Colors: olive gray (5Y 3/2) to (5Y 4/1), olive black (5Y 2/1); slightly deformed; mildly bioturbated.

SILT-RICH CLAY
Smear: CC

Texture	Composition
85-90% Clay	85% Clay minerals
10-15% Silt	7% Pyrite
	4% Feldspar
	2% Micarb
	1% Diatoms
	1% Quartz
	Tr% Glauconite

MICARB CHALK (Minor Lith)
Smear: 2-73

Texture	Composition
100% Clay	100% Micarb

Grain Size 1-12
0.2, 18.0, 81.8

Carbon Carbonate 1-15
0.9, 0.7, 2

X-ray 1-14 (Bulk)
32.7% Cris
19.9% Quar
17.0% Mont
12.0% Mica
7.5% Plag
4.2% Pyri
3.0% K-Fe
1.4% Trid
1.3% Chlo

Explanatory notes in chapter 1

Site 302 Hole Core 18 Cored Interval: 528.5-531.5 m

AGE	ZONE	FOSSIL CHARACTER: FORAMS	NANNOS	RADS	SILICO. DIATOMS	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
			B	B	B	1	0.5, 1.0	VOID		94, 105	5Y 3/2, 5G 4/1, 5G 5/2
		B	B			Core Catcher				CC	

Colors: olive gray (5Y 3/2), dark greenish gray (5G 4/1) to grayish green (5G 5/2)
Unit 5 at 529.4 meters.

SILT-RICH CLAYSTONE
Smear: 1-94

Texture	Composition
85% Clay	60" Clay minerals
15% Silt	15% Fe-oxide
	10% Feldspar
	5% Pyrite
	5% Zeolite
	5% Quartz

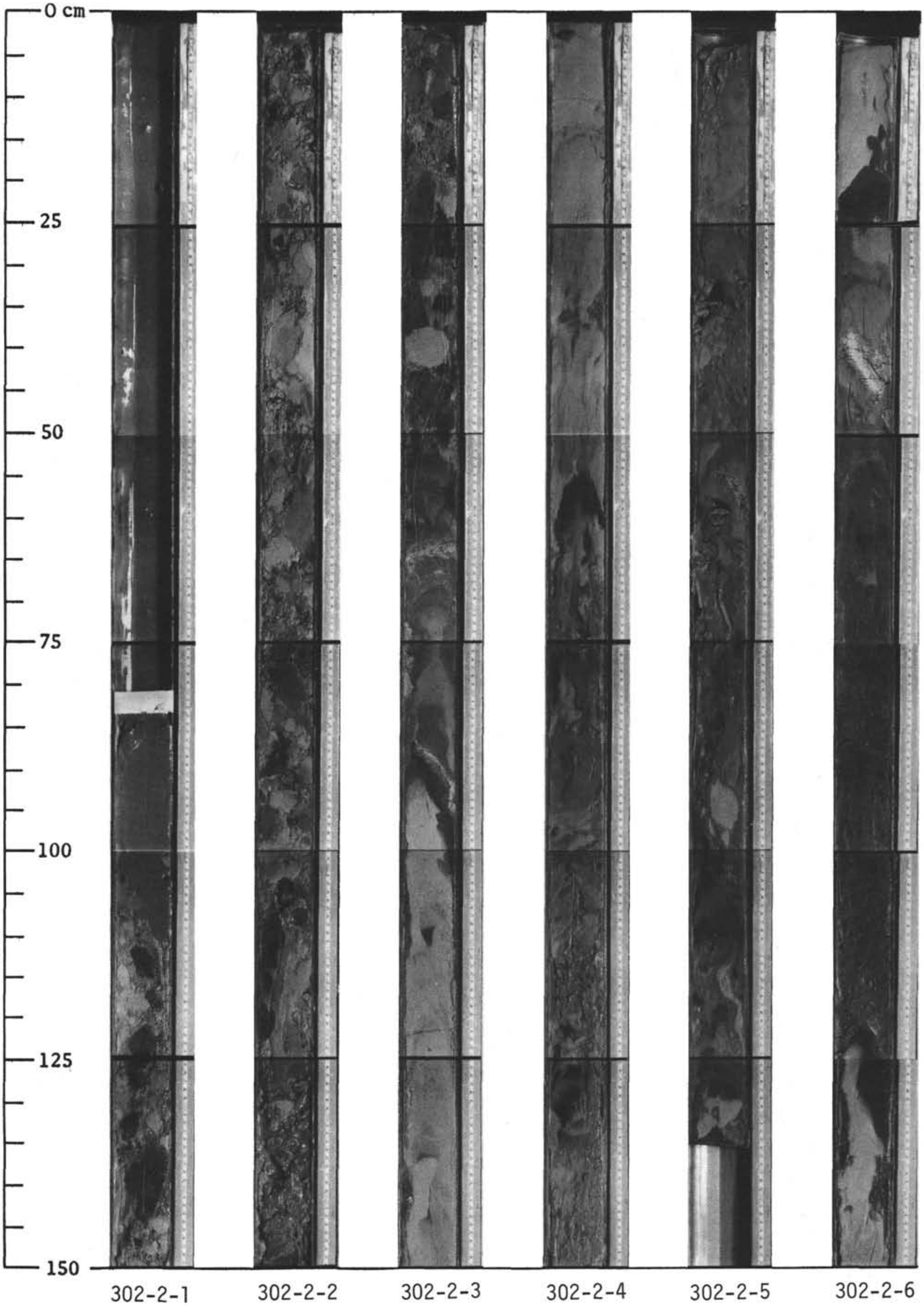
VOLCANIC SILTY SAND
Smear: 1-105

Texture	Composition
40% Sand	50% Devit. vol. lithics and volcanic glass
40% Silt	20% Heavy minerals
20% Clay	20% Feldspar
	10% Pyrite

DEVITRIFIED VOLCANIC ASH (Green Tuff)
Smear: CC

Texture	Composition
97% Clay	97% Devit. glass
3% Silt	3% Feldspar
	1% Pyrite

Explanatory notes in chapter 1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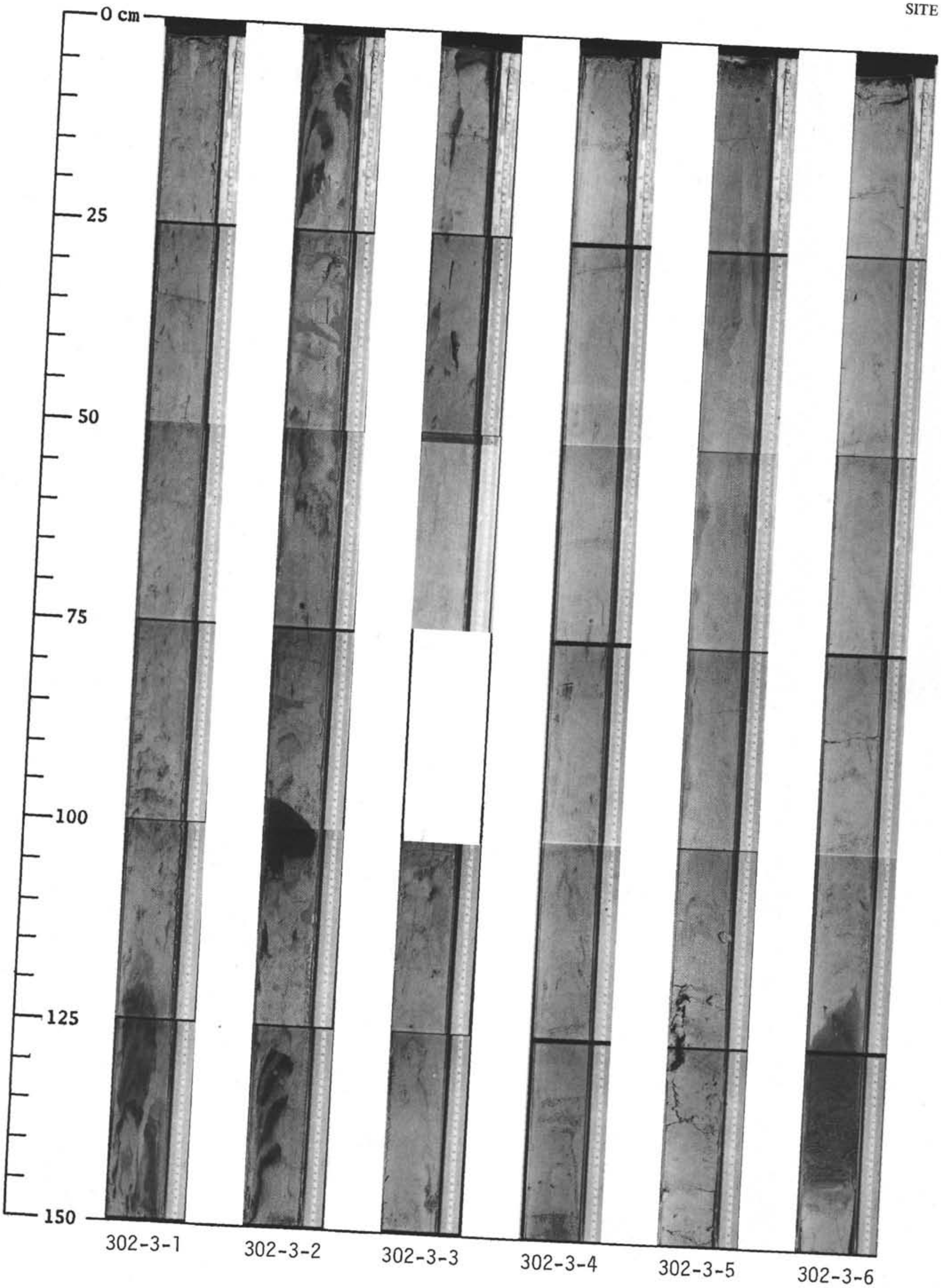
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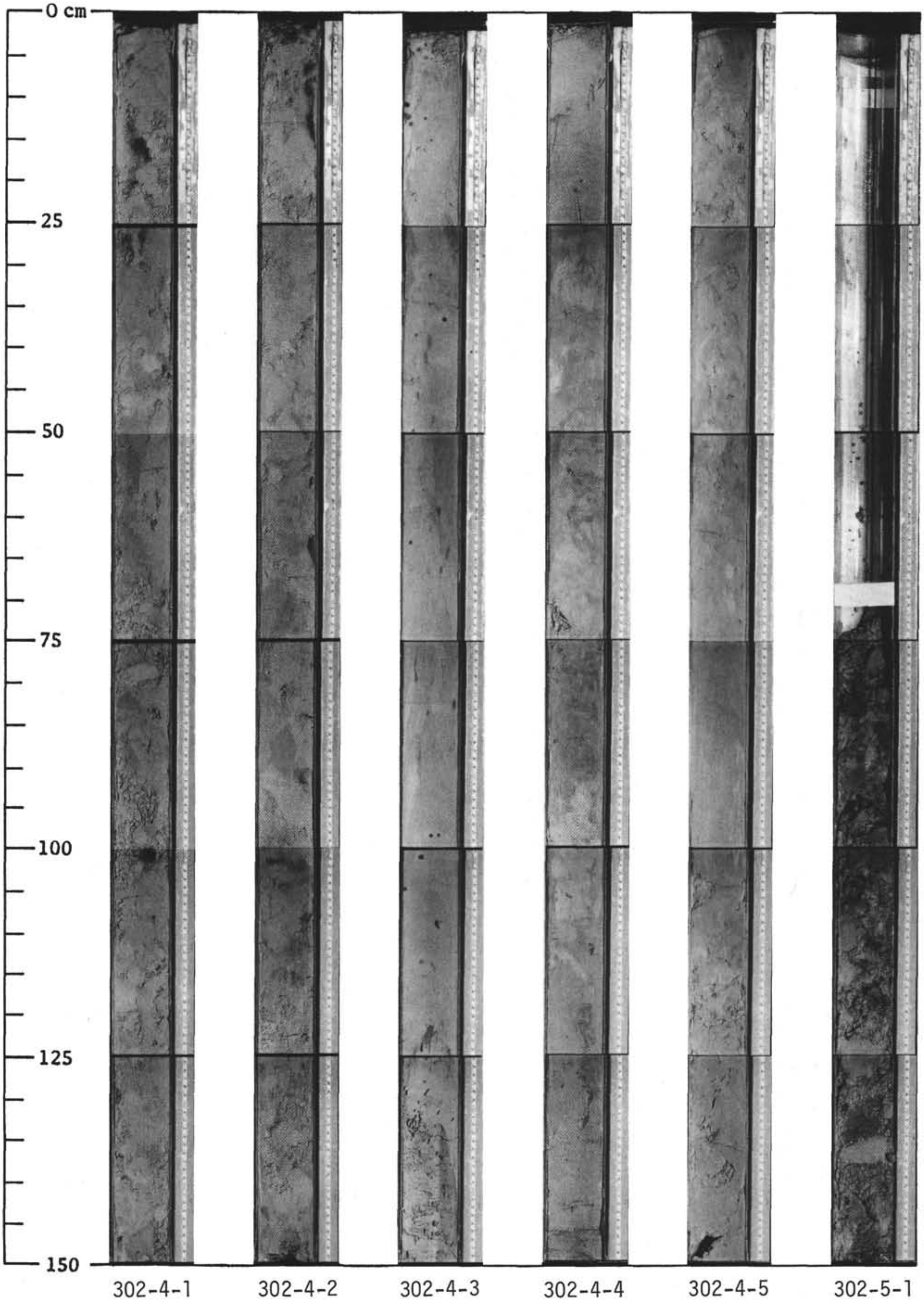
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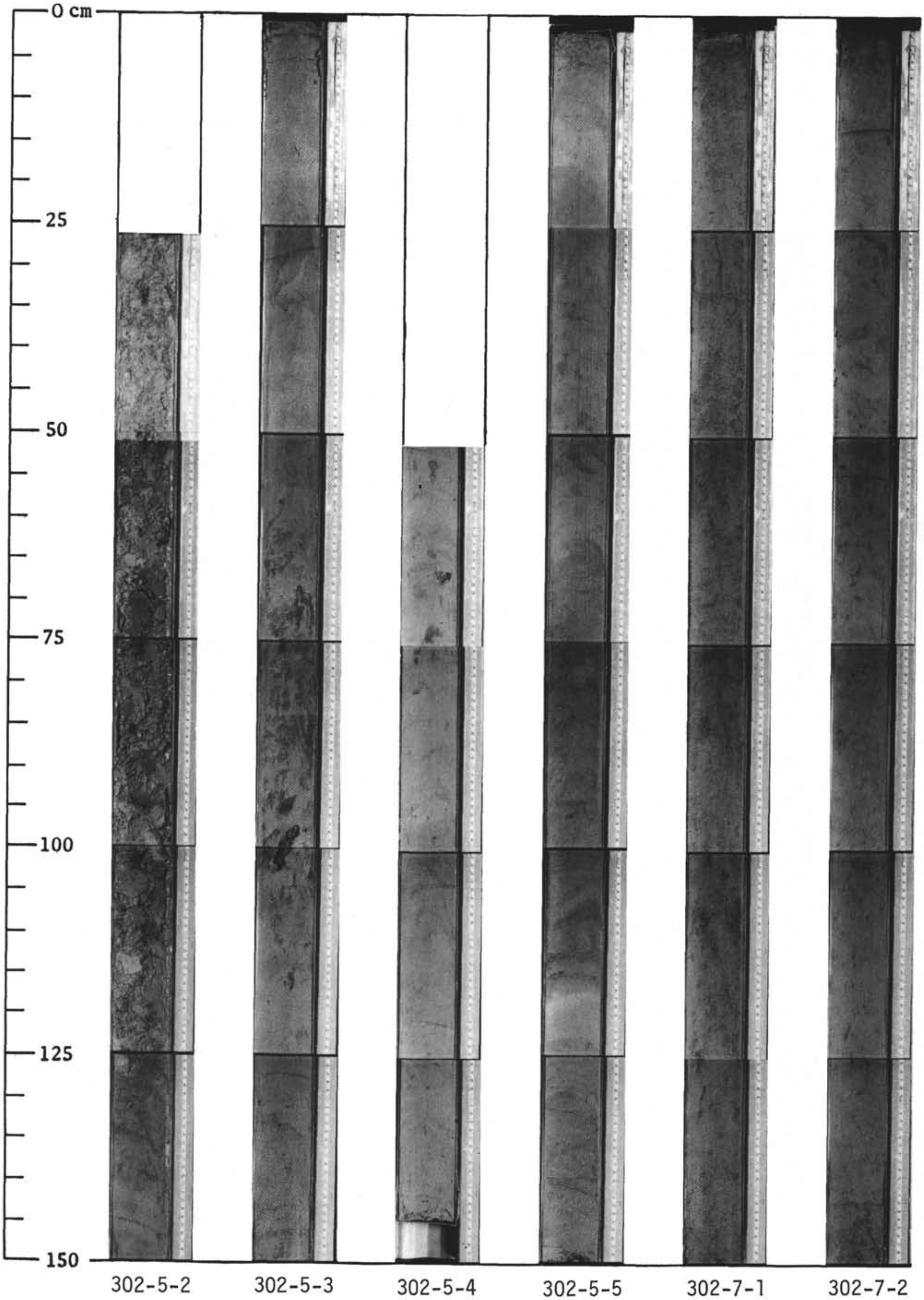
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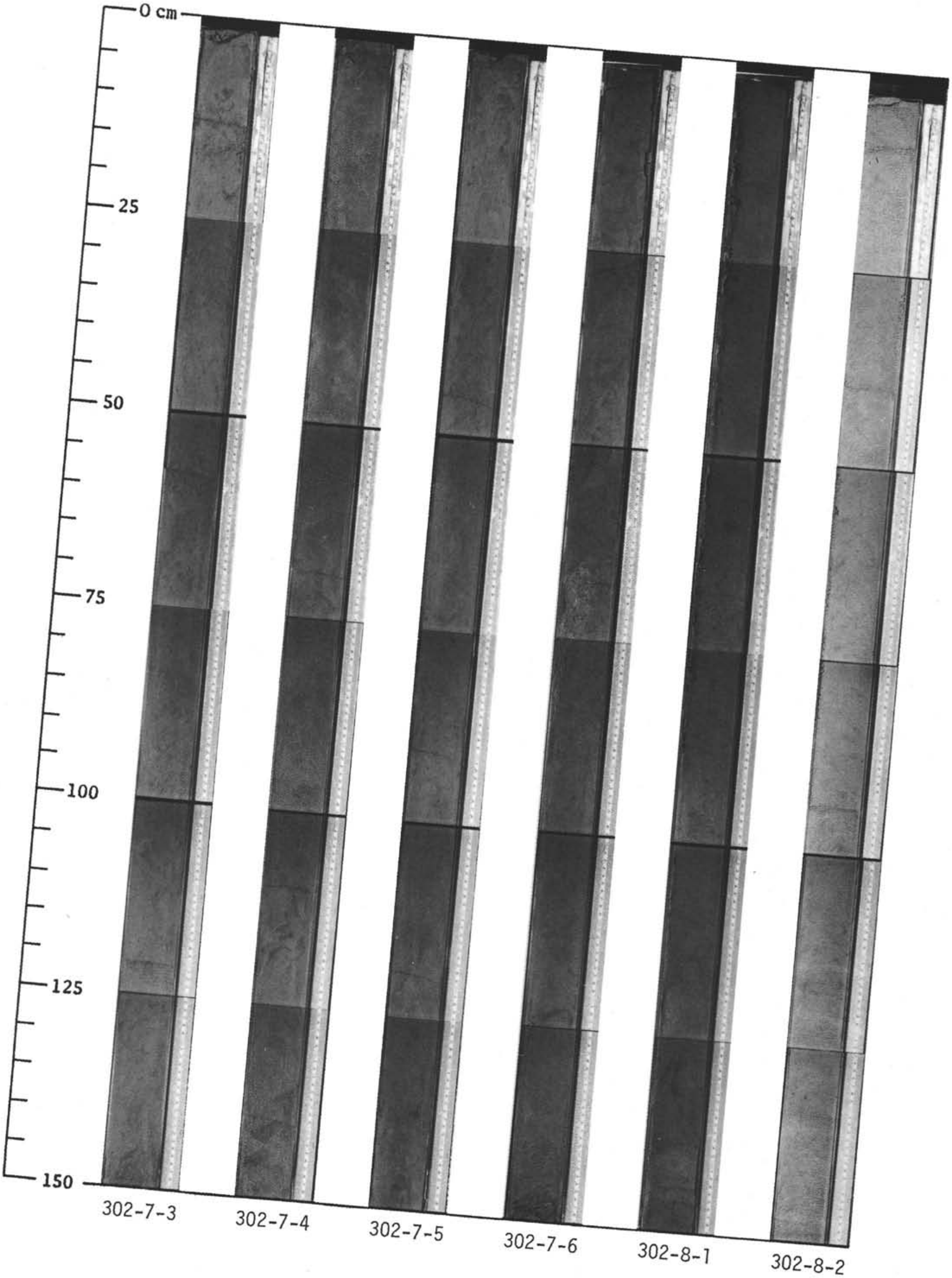
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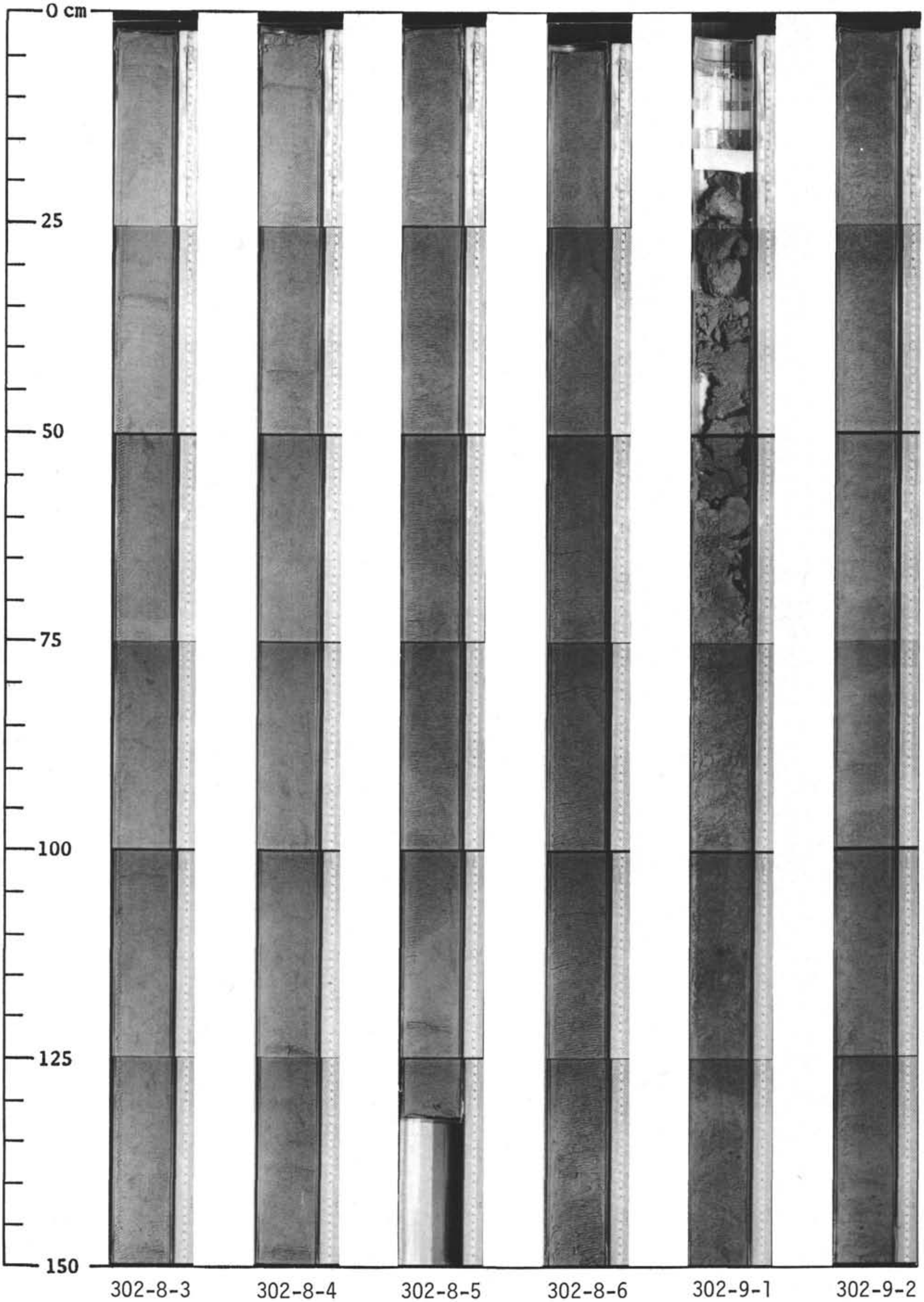
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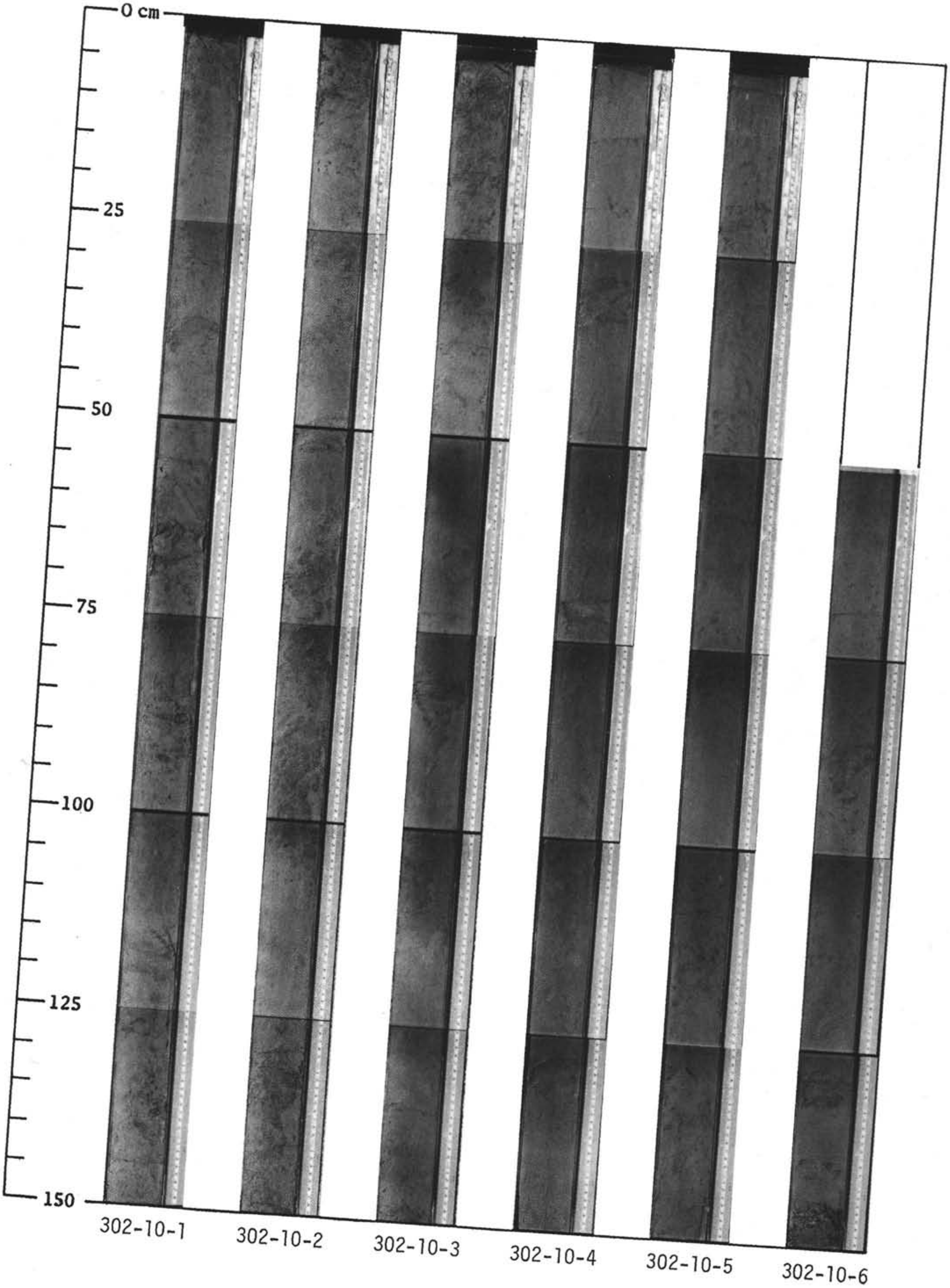
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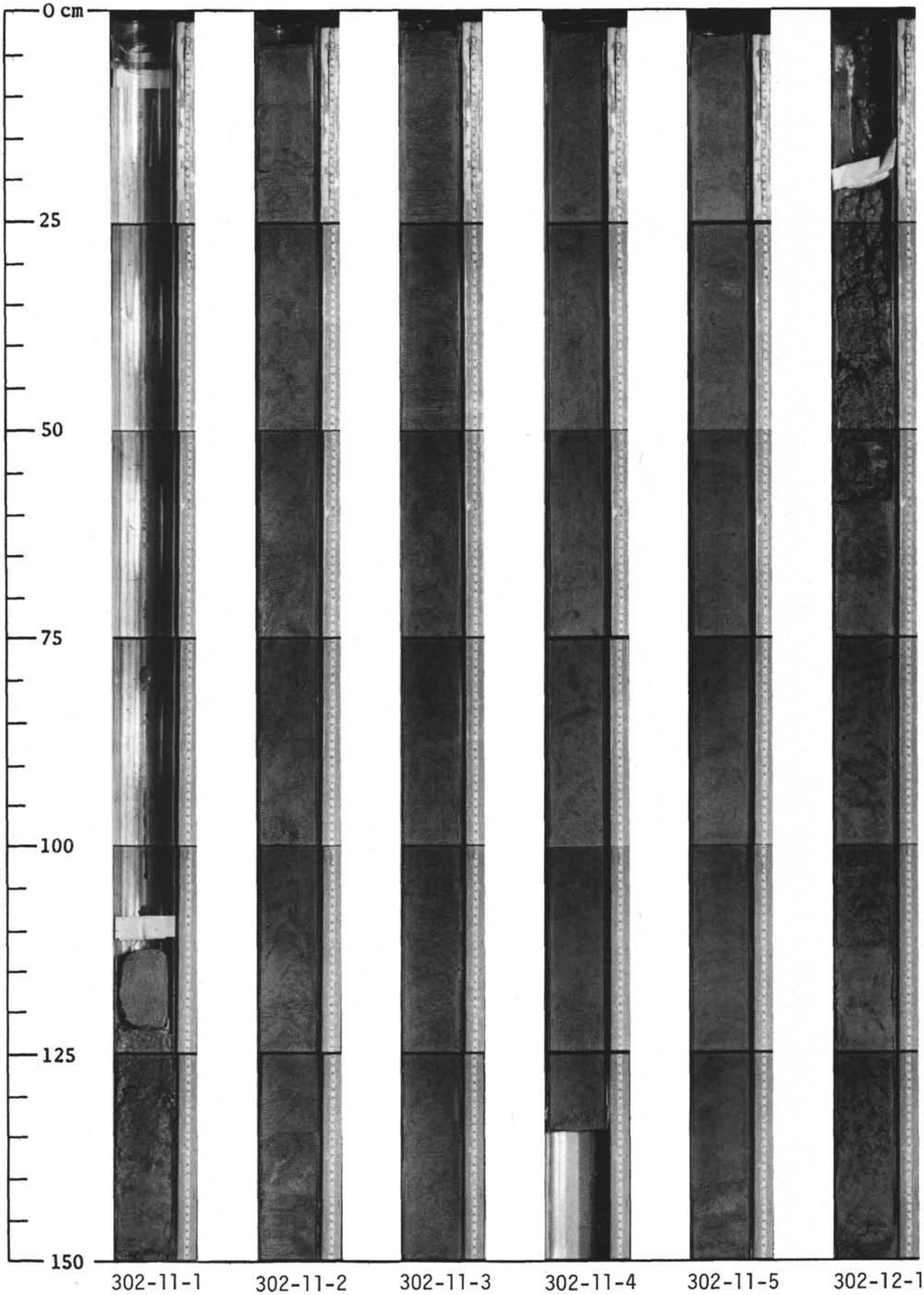
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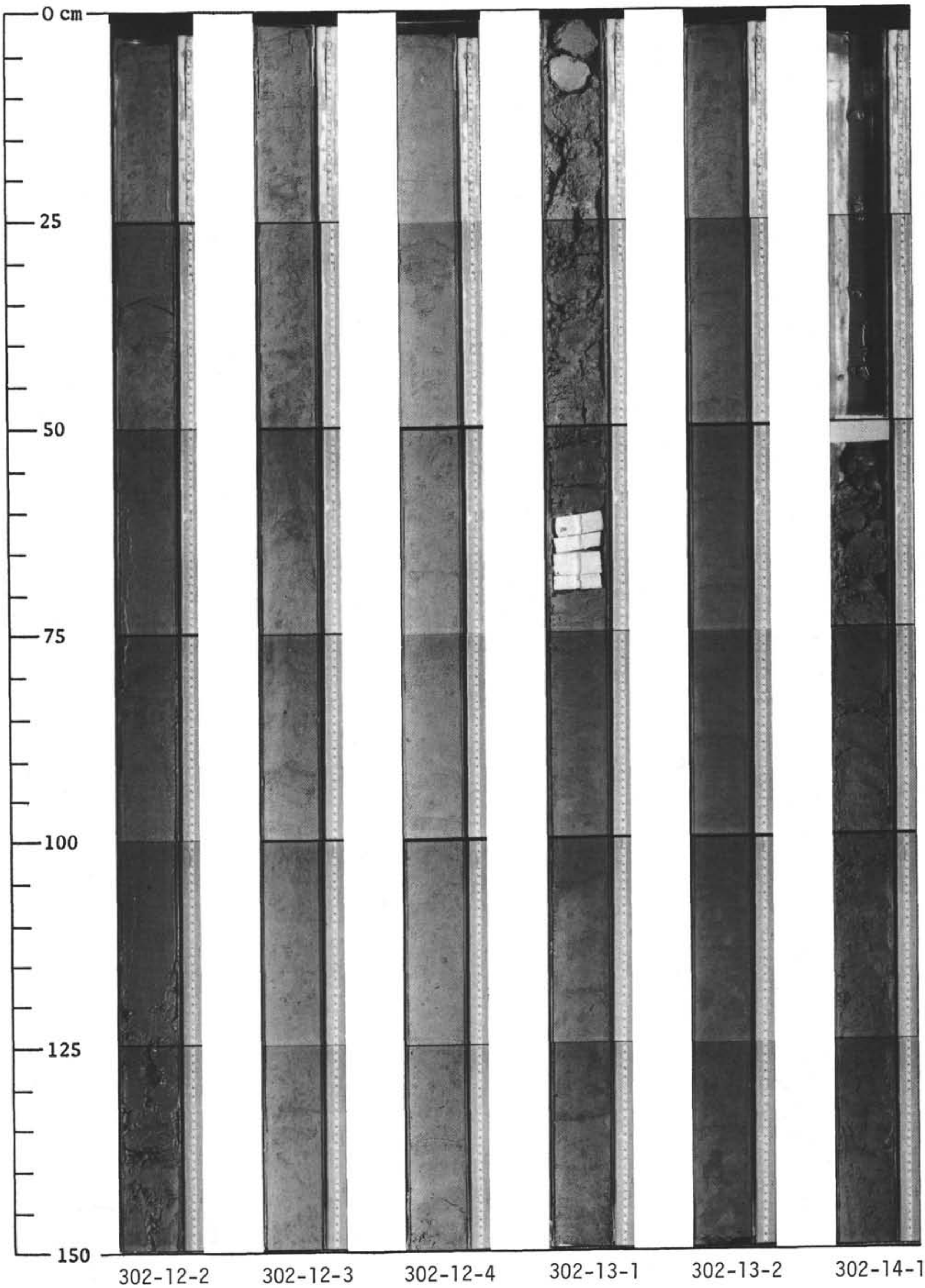
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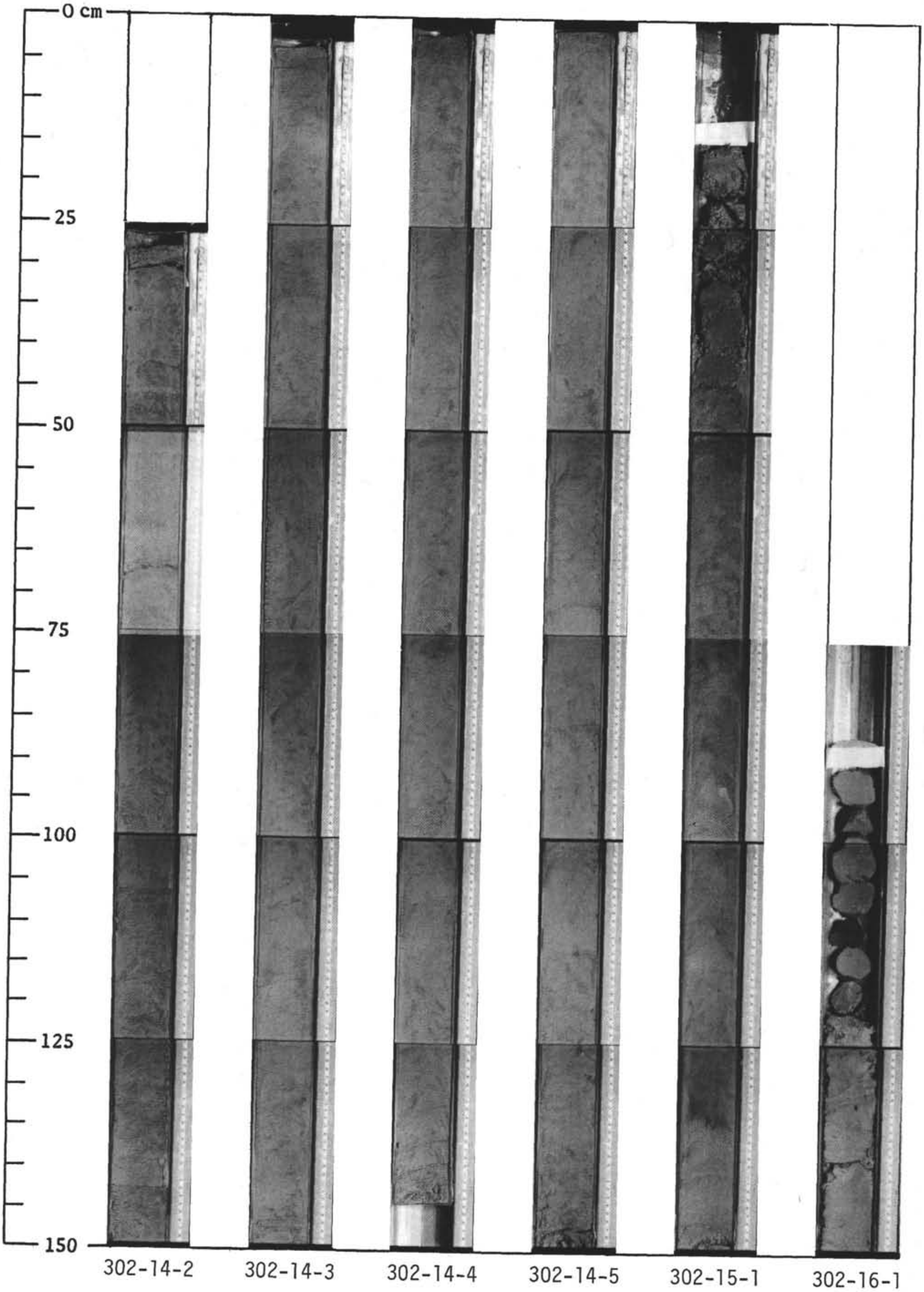
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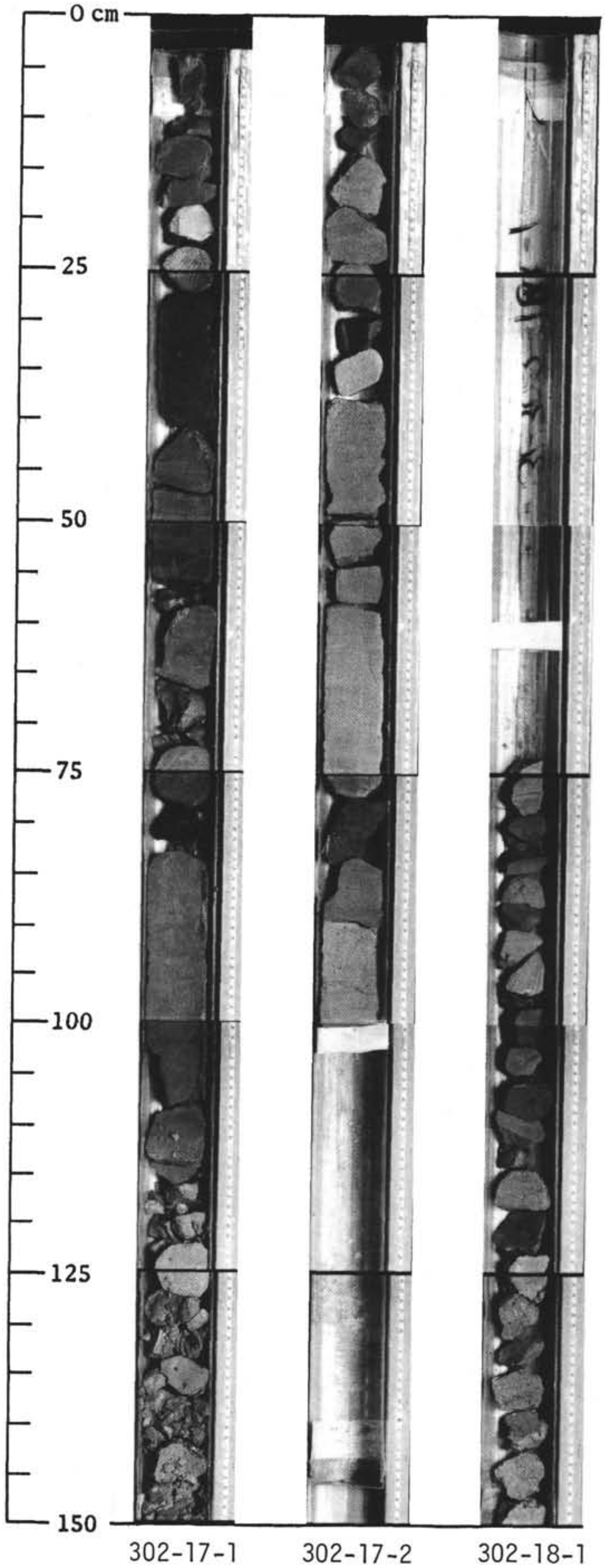
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