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# V. REGIONAL SEDIMENTOLOGIC DATA: THE CENTRAL PACIFIC WAKE-TAHITI TRANSECT, GH80-1 CRUISE

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## Introduction

Along the two traverses, Lines A and B in the Central Pacific, we obtained 29 short cores of sediment, up to 40 cm long in maximum, mainly with a double-spade box corer or with a single-spade box corer at a few stations, 60 "surface" sediments with a small cylinder (FG cylinder) attached to the free-fall grab, and 22 long sediment cores up to about 8 m in maximum with a GH80–1 type piston corer. Wire-lined sampling mainly with a double-spade box corer or a piston corer was conducted distancing about 60 or 100 n.m. each other along the traverses (Fig. V-1). The FG cylinder samples were collected from all the stations. The piston corer with installed thermograd-meter has a 8 m long barrel and the inside diameter of the inner tube of about 73 mm (see Fig. IV-1a).

For determination of general lithologic texture and composition about 350 smear slides were prepared, taken from the sediment samples, and were observed under the petrographic microscope. In addition, in order to examine the coarse fraction of the sediment samples, a few to several segments of the each short core and small segments at an interval of 50 cm in principle from the piston core were sieved through the sieve of 63 micron openings with water poured on it, and the coarse fractions thus obtained were provided for measurement of their volumetric ratio and determination of their compositions under the binoculars.

General procedure of the handling of the sediments was almost followed NISHIMURA (1981). Lithologic facies were determined according to the classification scheme shown in Table V-1, based on the results of observation of smear slide.

In this article, we present petrographic descriptions and discussions on some aspects of sedimentology concerning surface sediments and cores along the traverses. The discussions are also based on the data of micropaleontology by UJIIÉ and MISHIMA (Chap. XI of this cruise report) and TAKAYANAGI *et al.* (Chap. X) and remanent magnetization by JOSHIMA (Chap. XII).

## Distribution of surface sediments

### *General remarks*

Surface sediments are defined here as the uppermost part (a few centimeters in thickness) of box core or the sample with FG cylinder, the latter representing a depth of about 15 cm from the very surface.

Figure V-2 shows the lithology of the surface sediments and lithologic sequence down to depths of 30 to 40 cm when the data are available, along the two traverses. The following description is partly based on comprehensive consideration with the results of the previous cruises (ARITA, 1977; NAKAO, 1979; NISHIMURA, 1981).

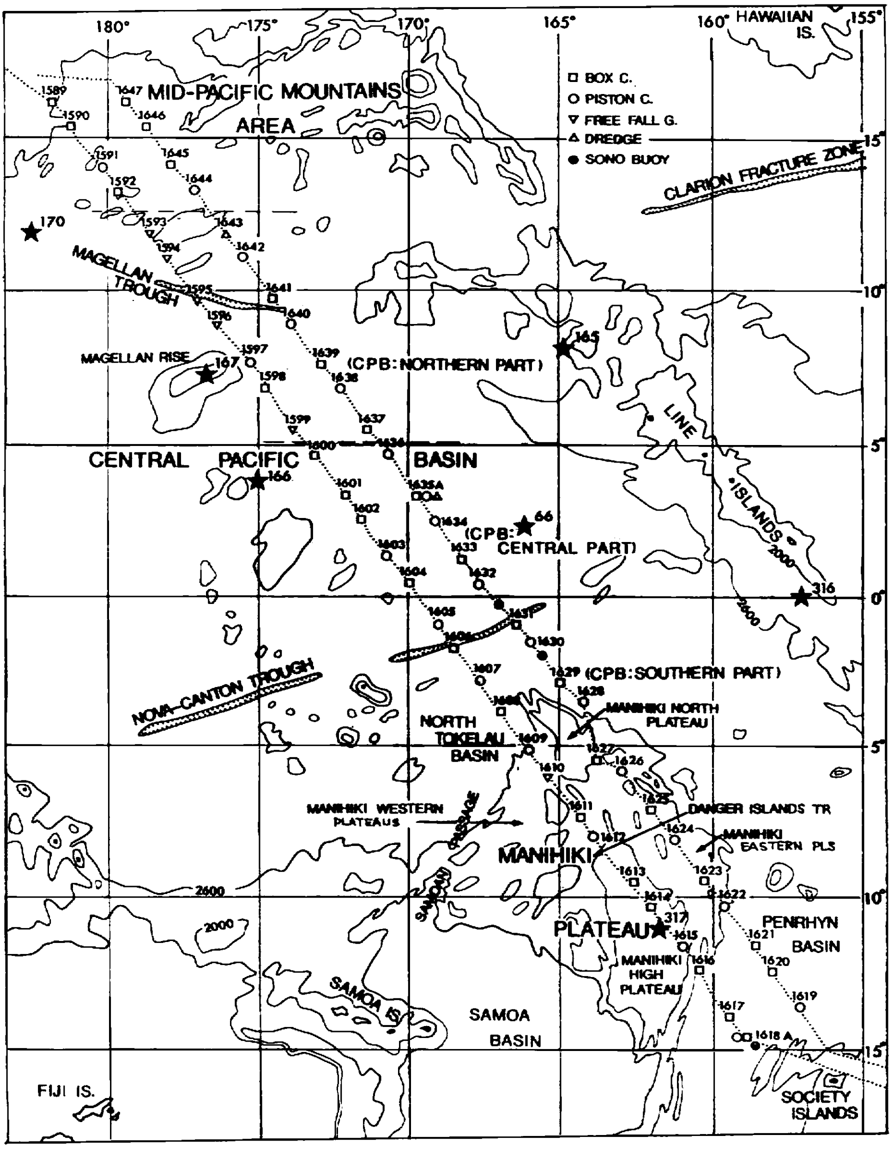


Fig. V-1 Sampling sites and major bathymetry, reproduced from Fig. 1-2.

Summarizing the available data along the traverses, we can discriminate a zonal arrangement of lithology of the surface sediment; pelagic clay zone in the Mid-Pacific Mountains area, transitional facies zone, equatorial siliceous biogenic zone, equatorial calcareous biogenic zone, and pelagic clay zone in the Penrhyn Basin, from the north to the south (see Fig. V-4). Major controlling factors for such distribution pattern of the surface sediment seem to be biogenic high productivity in the equatorial zone, bathymetry, possible ancient terrestrial and/or submarine volcanism, etc. during the Tertiary and the Quaternary.

Table V-1 Classification of sediment through the microscopic observation of smear slides.

| component / sediment name | calcareous microfossils | siliceous microfossils | zeolite minerals | clay and other authigenic minerals other than zeolite |
|---|---|---|---|---|
| | Foraminifera, Calc. nannos, etc. | Radiolarians, Diatoms, etc. | Phillipsite, Clinoptilolite, etc. | |
| Calcareous sediments | | | | |
| Calcareous ooze | >30% | * | * | <70% |
| Calcareous mud<br>clay | 10~30% | * | * | <90% |
| Calcareous fossils rich clay | 5~10% | * | * | <95% |
| Siliceous sediments | | | | |
| Siliceous ooze | * | >30% | * | <70% |
| Siliceous mud<br>clay | * | 10~30% | * | <90% |
| Siliceous fossils rich clay | * | 5~10% | * | <95% |
| Zeolitic sediments | | | | |
| Zeolitic mud<br>clay | * | * | >10% | <90% |
| Zeolite rich clay | * | * | 5~10% | <95% |
| Pelagic clay | * | * | * | |

*less than 5%

Underlined number means the primary index of classification.

*Pelagic clay zones in the northern and southern areas*

Dark to very dark brown or dark reddish brown pelagic clay (zeolite-rich in some sites) and zeolitic mud occur on the sea bottom surface in the Mid-Pacific Mountains (MPM) area in the north and the Penrhyn Basin (PB) in the south, at the depths of about 5,000 to about 5,700 m. The pelagic clay zones with such lithology are distributed in the MPM from St. 1590 to St. 1594 (Line A) and from St. 1647 to St. 1643 (Line B) and in the PB from St. 1616 to 1618 (Line A) and from St. 1622 to 1619 (Line B).

The sediments are usually barren in fossil and we have no positive evidence for their geologic age. However, NAKAO and SUZUKI (1981) have suggested that such type of surface sediment in the MPM area accumulated in the pre-Quaternary, and JOSHIMA (this cruise report) discusses a possibility of hiatus from the Matuyama epoch to the present in the sediment core from the PB. Zeolites in zeolitic mud or zeolite-rich clay are largely phillipsites, which have originated from ancient volcanic materials, in particular basaltic glass and palagonite, according to KASTNER and STONECIPHER (1978).

*Transitional zone in the northern area*

In the northern part of the Central Pacific Basin (CPB), south of the pelagic clay zone, we can find the transitional zone in lithology between the pelagic clay zone and the equatorial siliceous biogenic zone. The transitional zone occurs on Line A between Sts. 1595 and 1598 and on Line B between Sts. 1642 and 1638, at the depths around 6,000 m. Comprehensive consideration of our data with those by the previous cruises in this region shows that the lithology of surface sediment is represented by dark brown to dark yellowish brown siliceous fossil rich clay or siliceous mud (mainly with radiolarians) under-

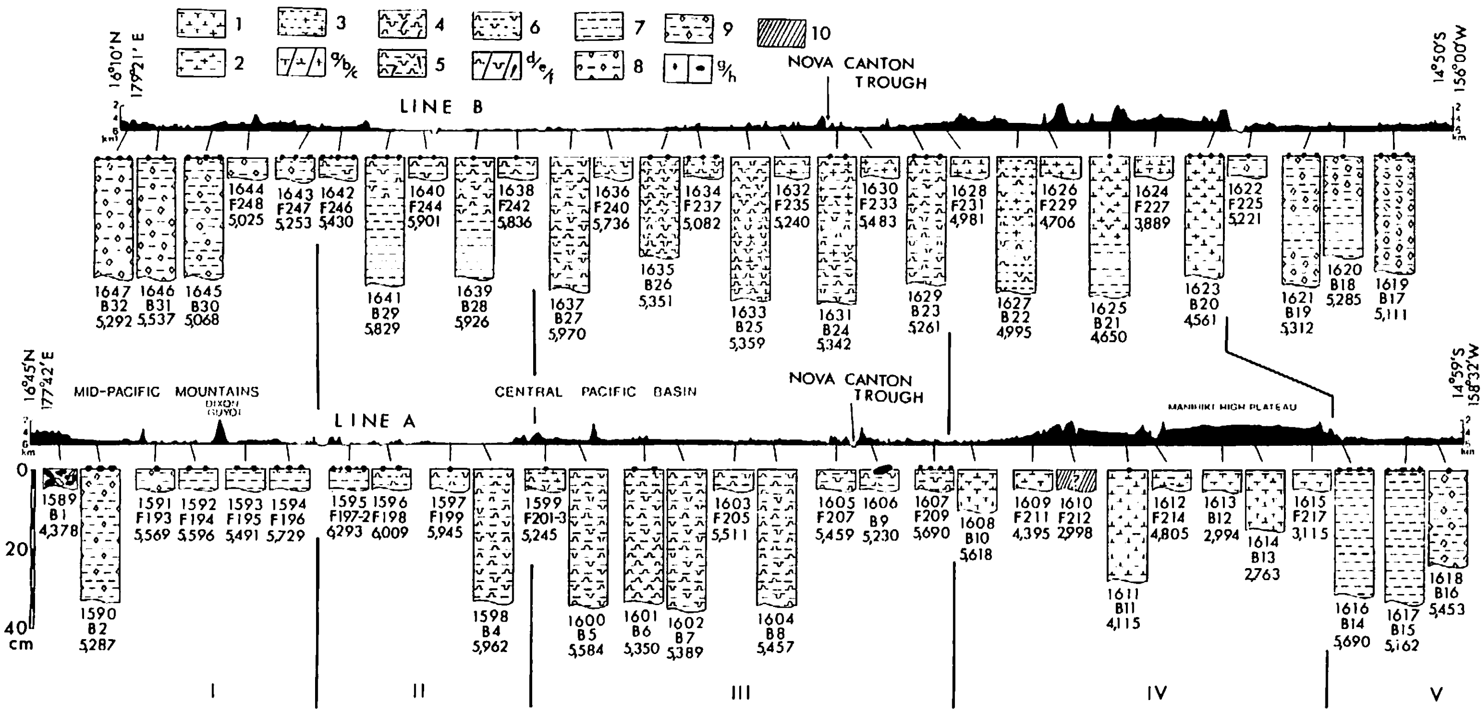


Fig. V-2 Lithology of surface sediment along Line A and Line B, as revealed by box core sampling and freefall grab sampling, showing five lithologic zones regarding the surface sediment (see also Fig. V-4). Three lines beneath the solumns show site data: four digits at the top, station number; three digits at the middle, sample number (F, by a freefall grab and B, by a box corer); and the bottom four digits, water depth in meter. Explanations for the legend: **1**, calcareous ooze; **2**, calcareous mud or clay; **3**, calcareous fossils rich clay; **4**, siliceous ooze; **5**, siliceous mud or clay; **6**, siliceous fossils rich clay; **7**, pelagic clay; **8**, zeolitic mud or clay; **9**, zeolite rich clay; **10**, consolidated rocks; **a**, foraminiferas; **b**, nannofossils; **c**, carbonates unspecified; **d**, radiolarians; **e**, diatoms; **f**, sponge spicules; **g**, manganese micronodules; and **h**, manganese nodules.

lain by pelagic clay or zeolitic mud. The siliceous fossil rich clay or siliceous mud layer is 10 to 20 cm thick. The surface siliceous layer may indicate the extended or delaied earliest Pliocene phase of high supply of opal in the central equatorial Pacific, southeast of the Hawaiian Islands (LEINEN, 1979).

*Equatorial siliceous biogenic zone*

On the south of the transitional zone siliceous sediments are extensively distributed in the central to southern parts of the Central Pacific Basin, between around 6°N and 3°S (from St. 1599 to St. 1607 on Line A and from St. 1637 to St. 1629 on Line B at the depths of 5,300 to 6,000 m). The lithology is only represented by dark brown to dark yellowish brown siliceous mud or ooze accompanied by a lot of radiolarians, diatoms, and sponge spicules. It occurs not only in the entire section of box core but also extends to the entire section of piston core. In shallower sites than about 5,300 m deep in this zone, we can find calcareous mud or ooze (for example St. 1599; depth, 5,245 m). The lithologies reflect the biogenic high productivity particularly of siliceous organism in the equatorial region. The differentiation of calcareous facies and perfectly siliceous one may owe to dissolution of calcareous biogenic materials in deeper waters.

*Equatorial calcareous biogenic zone*

On and around the Manihiki Plateau calcareous biogenic sediments are distributed (St. 1608 to St. 1615 on Line A and St. 1628 to St. 1623). These represent the equatorial calcareous biogenic zone. Bathymetry varies from about 5,600 m (St. 1608) to about 2,800 m (St. 1614). Dominant lithology is nannofossil ooze (clayey in many cases), nannofossil-foraminiferal ooze, or foraminiferal ooze with various colors of very pale brown, yellowish brown, dark yellowish brown, brown, etc. Nannofossil mud is distributed in the Danger Islands Trough. Dark yellowish brown siliceous fossil rich nannofossil ooze (clayey) occurs in the northern end of Line B (St. 1628), suggesting a possible presence of the transitional facies to the equatorial siliceous biogenic zone. Peculiar feature is that white to very pale brown nannofossil-foraminiferal ooze occurs at a depth of about 5,600 m in the northern end of Line A (St. 1608 in the North Tokelau Basin). From micropaleontological evidence the ooze seems to be of the late-latest Pliocene or earlier (A. NISHIMURA, personal communication). Equatorial (4°N to 4°S) CCD had been shallower than 5,000 m through the Tertiary (VAN ANDEL *et al.*, 1974), whereas it is now somewhat below 5,000 m (BERGER and WINTERER, 1974). Local subsidence of about 600 m deep after the deposition is unlikely, hence the distribution of calcareous sediment reaching to anomalous deep seems to have been resulted from unexpectedly high productivity of calcareous planktons probably of local, or redistribution of the sediments. No conclusion can be given to this problem from the present data, and future study is needed for the solution.

The calcareous biogenic zone reflects the biogenic high productivity in the equatorial region as the siliceous biogenic zone does. The differentiation of both facies is thought to have been caused by dissolution of calcareous materials in deeper water. On the south the calcareous biogenic zone seems to be in contact with the pelagic clay zone in the Penrhyn Basin without either siliceous biogenic or transitional facies in-between. Outlined regional sedimentary facies by RAWSON and RYAN (1978) (Fig. V-3) also

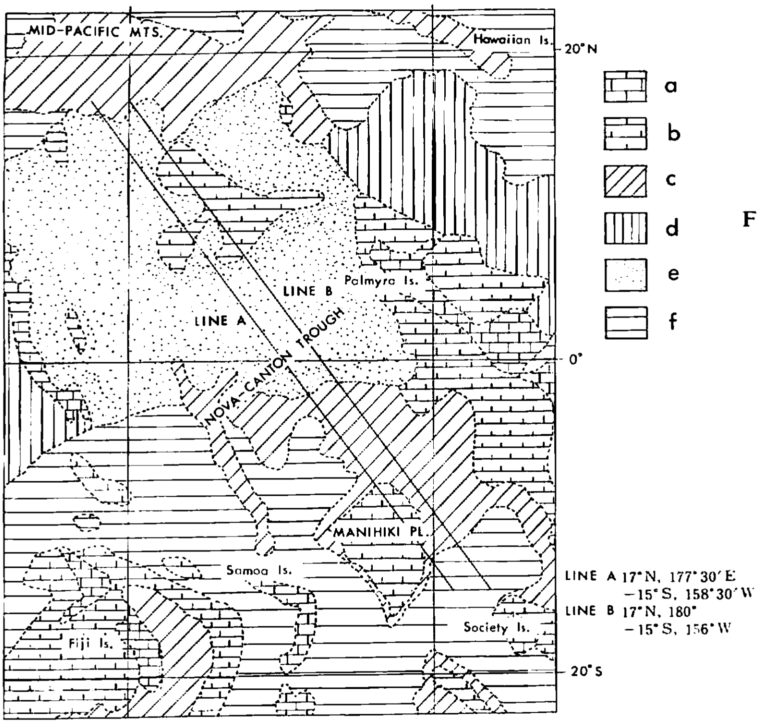


Fig. V-3 Distribution of surface sediment in the Central Pacific after Rawson and Ryan (1978). The two traverses in GH80 cruise are indicated by parallel solid lines. a, calcareous ooze; b, calcareous marl; c, calcareous clay; d, siliceous ooze; e, siliceous mud; and f, pelagic clay.

suggests the assymmetrical distribution of lithology with respect to the equator without siliceous facies in the southern hemisphere part. The lack of the siliceous biogenic or transitional facies south of the calcareous biogenic zone may have been derived from a low productivity of siliceous organisms in the southern equatorial belt of the central Pacific Ocean.

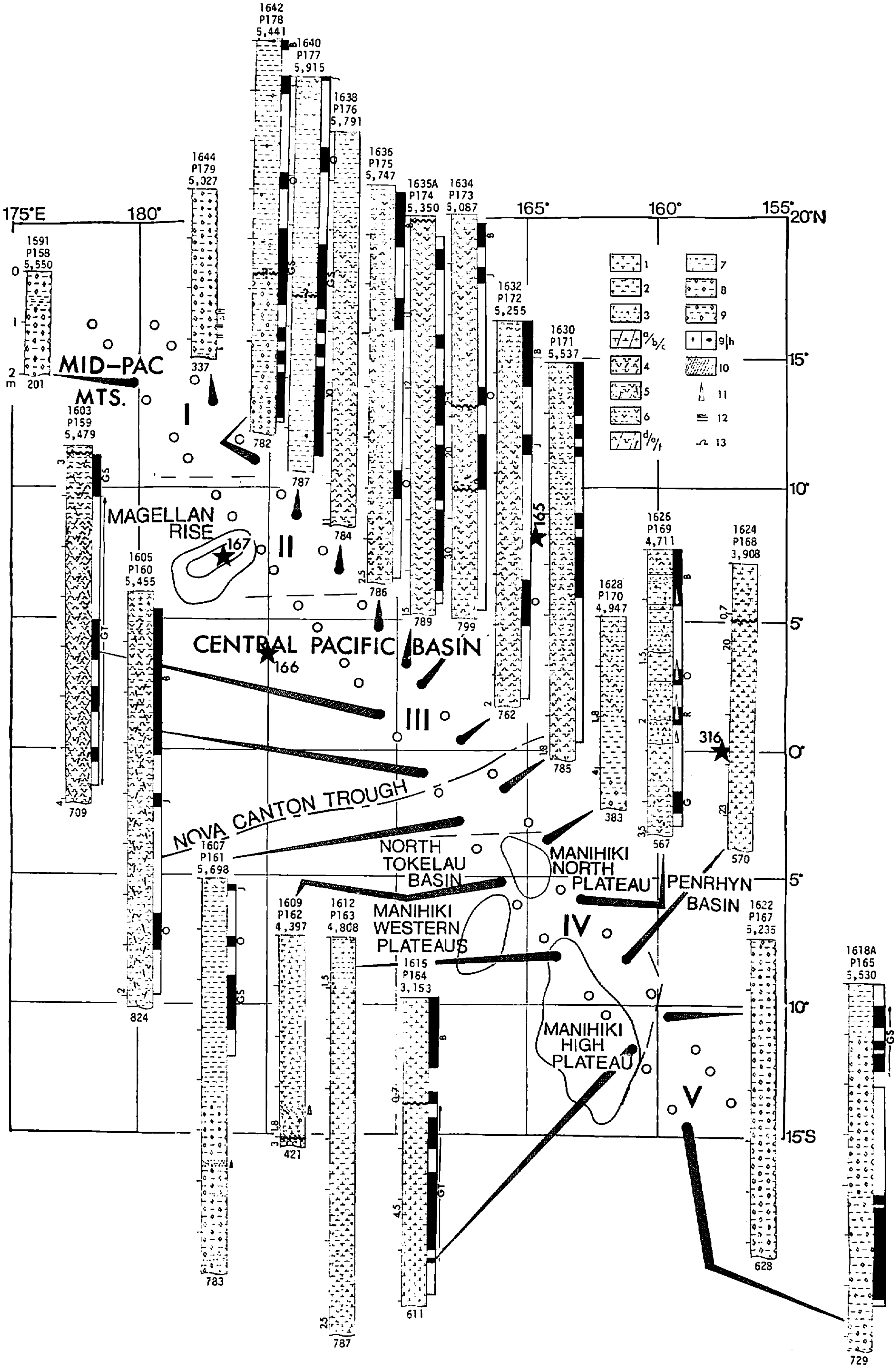
*Remarks on some modification of previous lithologic map*

From the above-described data on surface sediments, we can give some modifications to a part of the map, "Ocean Floor Sediment and Polymetallic nodules," by Rawson and Ryan (1978). In terms of their classification scheme of surface sediment, the major results are: 1) extensive distribution of pelagic clay north of the latitude around 8°N for their "siliceous mud" and "calcareous marl"; 2) partial distribution of siliceous ooze along Line B (1°N–4°N) in the area of "siliceous mud" by them; and 3) extensive distribution of calcareous ooze on and around the Manihiki Plateau where "calcareous clay" and "calcareous marl" are drawn on their map.

## Regional distribution of lithologic facies of piston cores

Figure V-4 illustrates an outlined view of lithologic sequence of 21 piston cores with

Fig. V-4 Outlined view of all cored sediments with the data of remanent magnetization by Joshima (this cruise report). Legend for lithology is common to that in Fig. V-2 except for additional one (11, graded bedding; 12, parallel lamination; and 13, microfolding). The site data are described above the columns and the length of cores are beneath the columns in cm; numerals on the left of each column indicate an approximate age of given position of core from micropaleontologic analysis, and symbols of capital letter on the right show identified magnetic epoch or event (B-Brunhes epoch, J-Jaramillo event, O-Oldvai event, R-Reunion event, GS-gauss epoch, and GT-gilbert epoch). Possible hiatus inferred from micropaleontologic and/or magnetic data is indicated by a wavy line inside a lithologic column. I to V show surface sediment zones: I, pelagic clay zone in the MPM area; II, transitional zone; III, equatorial siliceous biogenic zone; IV, equatorial calcareous biogenic zone; and V, pelagic clay zone in the PB. Broken lines does a boundary of the sediment zones.


175°E
180°
165°
160°
155°
20°N
15°
10°
5°
0°
5°
10°
15°S
MID-PAC MTS.
MAGELLAN RISE
CENTRAL PACIFIC BASIN
NOVA CANTON TROUGH
NORTH TOKELAU BASIN
MANIHIKI NORTH PLATEAU
PENRHYN BASIN
MANIHIKI WESTERN PLATEAUS
MANIHIKI HIGH PLATEAU
I
II
III
IV
V
167
166
165
316
1591 P158 5,550
201
1644 P179 5,027
337
1642 P178 5,441
782
1640 P177 5,915
787
1638 P176 5,791
784
1636 P175 5,747
786
1635A P174 5,350
789
1634 P173 5,087
799
1632 P172 5,255
762
1630 P171 5,537
785
1628 P170 4,947
383
1626 P169 4,711
567
1624 P168 3,908
570
1603 P159 5,479
709
1605 P160 5,455
824
1607 P161 5,698
783
1609 P162 4,397
421
1612 P163 4,808
787
1615 P164 3,153
611
1622 P167 5,235
628
1618A P165 5,530
729
0
1
2
m
GS
GT
B
J
R
G
1
2
3
a/b/c
4
5
6
d/e/f
7
8
9
g|h
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11
12
13

the data of magnetic stratigraphy and approximate age determination by micropaleontology, excluding P166(St. 1619) which was largely disturbed at the time of sampling. Detailed lithologic description of individual core is in Appendix V-1. Lithologic facies of the cores are generally identical with those of surface sediments except for the cores, P161, P163, P170, and P177. The following descriptions will be for each topographic province (see Chap. I).

### *Mid-Pacific Mountains area*

Two cores, P158 (St. 1591) and P179 (St. 1644) were obtained from the Mid-Pacific Mountains area (MPM area). Dark brown to dark reddish brown zeolitic mud dominantly occurs throughout their entire sections. The both contain phillipsite of approximately 30% in general. The entire core of P158 and the upper half of P179 is structureless, but the lower half of the latter is characterized by some kinds of sedimentary structure. In P179, Zeolitic mud resting upon hard chert of older age (Eocene?) with a sharp boundary is stiff and contain minor slump folds, thin graded laminae, thin layers of sand, and a small lense of volcanic glass (at an Interval of 2.3 to 3.2 m). This interval gradually passes upward to massive zeolitic mud.

Seismic reflection records show that the MPM area is largely underlain by older sediments of Unit II (Eocene-Cretaceous) with little distribution of younger transparent layer. On the other hand, a thin veneer of the uppermost transparent layer is detectable on 3.5 kHz records. It is measured 5 m thick or so at Sts. 1591 and 1644 (App. I-2). P158 (ca. 2 m long) and P179 (ca. 3.4 m long) represent its upper half and entire section, respectively. Magnetic and micropaleontologic data are not available for the cores, so their geologic age is not certain at the present time. However, the surface part may be the pre-Quaternary (although can not be specified) as mentioned before, and this suggests a non-depositional or erosional environment in the younger age. Also, it seems that there had occurred a very slow sedimentation of clay in the environs of DSDP Site 170 (WINTERER, EWING, *et al.*, 1973), which was associated with that of very fine volcanic ash at both the stations and other part of the MPM area during the time of sedimentation.

### *Central Pacific Basin*

Eleven cores are available for descriptions. They were studied magnetically and/or micropaleontologically. Siliceous fossils (radiolarians, diatoms, and sponge spicules) are generally dominant in the cores except in those from the northern part of the Central Pacific Basin (CPB).

Cores P178, P177, and P176 in the northern part of the CPB, located almost in the transitional facies zone of the surface sediment, contain more or less pelagic clay facies. However, the detailed features of lithological sequence and geologic age are not identical with each other. Dark brown pelagic clay occupies the upper half of P178 (St. 1642). It passes downward to zeolite rich clay and in turn to zeolitic mud (ca. 4.7 m to the bottom). In P177 (St. 1640) the uppermost 40 cm part is replaced by dark brown siliceous mud and the remaining is entirely composed of brown to dark brown or dark reddish brown pelagic clay. The sediments of both cores are structureless except for mottles by bioturbation. Micropaleontologic data are not available, but magnetic data show that the both cores are very similar to each other in magnetic sequence. From the viewpoint of remanent magnetization, core P177 includes a possible hiatus at a level of 4.2 m, though there is no visible sign in the core indicating the hiatus. If it is the case, the case, the possible hiatus can be inferred near a level of ca. 4.7 m in core P178 on the basis of a magnetic pattern. Above the hiatus almost continuous sedimentation is recognized from the Gauss epoch to the earliest Brunhes (P178) and to the earliest Jaramillo (P177). Non-deposition or erosion during the later ages may have occurred in both the stations. An interpretation of the magnetic pattern below the hiatus in both cores is very difficult. The pattern may not represent the Gilbert epoch but does older one (Miocene ?), and we can not give a conclusion to this problem at the present time.

Core P176 (St. 1638) comprises siliceous mud (only at the top), pelagic clay, siliceous fossil rich clay, and siliceous ooze with rind burrows and chondrites in descending order. There are some black fringes above and below a light colored burrow (Fig. V-5). They may result from reprecipitation of manganese as an oxide, which was once dissolved from

Fig. V-5 An example of biogenic reduction, dissolution, and reprecipitation of manganese. The black fringes above and below the light colored possible rind burrow may result from reprecipitation of manganese as an oxide, which was once dissolved from the burrow, as suggested by HARTMANN (1979). Width of the split core is 7.5 cm. Core P176 (St. 1638). Loc. 6°48.65'N, 172°15.46'W. W.D. 5791 m.

the burrow. HARTMANN (1979) attributed this phenomenon to biogenic reduction of sediment. No magnetic data is available for the core, but micropaleontologic evidence shows that the siliceous ooze at least may be of the middle to late Miocene. The uppermost part is possibly the Quaternary, but the remaining part is still open in geologic age. We may expect a hiatus within the part, which might be equivalent with the possible hiatus in cores P178 and 177.

Acoustic records in this area show that a transparent layer (Unit I) overlying Unit II tends to thicken southward. The tendency is clearer along Line B than Line A; Unit I along Line B generally less than 15 to 20 m thick suddenly thickens southerly to 100 to 140 m thick beyond the Magellan Trough. Similar change in thickness of transparent layer can be detected on 3.5 kHz records. Cores P177 and P178 represent approximately an upper half of the thinner sequence of Unit I, whereas core P176 only represent the uppermost section of thicker Unit I in the south.

Cores from *the central part of the CPB*, which are in the equatorial siliceous biogenic zone in terms of surface sediment zone, are very much dominated by siliceous fossils and are comprised by yellowish brown, brown, or dark brown siliceous ooze and/or siliceous mud through the entire sections of all the cores. The sediments are more or less bioturbated, with irregularly shaped mottles, rind burrows, halo burrows, *Chondrites*, *Teichichnus*, and/or *Zoophycos*. A few exceptions of lithology are encountered in the cores from St. 1634 (P173), St. 1632 (P172), and St. 1605 (P160). Core P173 contains siliceous-calcareous marly ooze and siliceous nanno ooze in the top and the bottom, respectively. P172 is rich in nannofossils particularly in the upper 1 m interval and is scattered by them through the remaining part. P160 is occupied by siliceous-calcareous mud in its uppermost 40 cm part. Most of the cores were taken from the bottoms shallower than the surrounding basin.

The chronological range of the cores is greatly variable, from micropaleontologic and/or magnetic evidences. The cores from abyssal basin area underlain by thick transparent layer of acoustic Unit I range from the early or late Pliocene to the Quaternary (Cores P159, 160, 172, and 175). However, their detailed sequence differs from each other. Core P160 shows a continuous sedimentation of siliceous mud with steady rate (3.82 mm/1000 yrs) (see Chap. XII) during the latest Pliocene to Quaternary. Cores P172 and 175 are similar to P160 in general sequence of core, but the sediments of the Brunhes epoch are thinner, suggesting any geological process of slowed sedimentation, non-deposition/erosion in the youngest age, or hiatus within the epoch. A definite hiatus was encountered in Core P159. The core comprises very thin Quaternary siliceous mud and Gilbert-early Gauss siliceous mud and ooze which occupy almost entire section. We can find a hiatus of 2 to 3 million years after the early Gauss epoch from micropaleontologic and magnetic data.

Much more marked events are found in P174 (St. 1635A) and P173 (St. 1634) which came from a topographic high elevated 300 to 700 m from nearby abyssal basin area. Thin Quaternary veneer seems to rest on the middle Miocene with a hiatus in P174.

In P173, approximately 3.8 m thick Quaternary sediment covers underlying early Miocene one which in turn covers late Oligocene one with hiatuses. The Quaternary part is characterized by shortened interval of the Brunhes epoch, implying the similar event as in Cores P172 and P175. In case of P173 and P174 the hiatuses may have been related to intensified influence of bottom current on the topographic highs. The seismic reflection and 3.5 kHz records indicate relatively poor development of Unit I as compared with surrounding basin area (Unit I, 35 to 40 m thick at St. 1634 and little developed at St. 1635A).

Two cores were obtained from *the southern part of the CPB* in the southern area of the equatorial siliceous biogenic zone regarding surface sediment. They contain siliceous fossils as well, but their amount is much reduced, and the decreasing southward seems to be remarkable, examining the two cores. Core P171 consists of siliceous mud with an intercalation of siliceous fossils rich clay (0 to ca. 6 m) and underlying siliceous ooze. In core P170 siliceous fossils rich nanno ooze and siliceous fossils rich clay occur in the upper half part (0 to 2 m), and pelagic clay which passes zeolite-micronodule rich clay downward (2 to 3.8 m) underlies the part. The sediments may be assigned to the Quaternary (P171) and the Pliocene to Quaternary (P170), but the details are still open.

*North Tokelau Basin*

Two cores, P161 (St. 1607) and P162 (St. 1609) from the basin are very different to each other in lithology. The former consists of dark brown to very dark brown pelagic clay (upper half) and very dark brown zeolitic mud with sandy or silty thin layers (lower half), except for the uppermost dark yellowish brown siliceous mud. In the lower half part a graded interbed composed of granule, sand, and silt occurs. On the other hand, core P162 largely consists of calcareous ooze, obtained from a depth of about 4,400 m. The calcareous ooze is dominated by white to very pale brown nanno-foram ooze with scattered manganese micronodules. A possible hiatus occurs in the lowest part of the core. The lower part of the upper section (Quaternary) above the possible hiatus of about 1 million years includes a graded gravel-granule layer consisting of marl, chalk, manganese nodule, and claystone (ca. 3.3 to 3.5 m), suggesting a reworking process at the depositional time. The section below that is represented by gravels with same nature as above and is considered as of the Pliocene. In terms of the surface sediment zone, St. 1607 is located in the southern end of the equatorial siliceous biogenic zone, whereas St. 1609 is in the equatorial calcareous biogenic zone.

The seismic reflection record at St. 1607 shows that uncosolidated sediments may not exceed 20 m in thickness, and thus the obtained core represents almost their upper half of which upper 3 m-interval may be thought to be of the Gauss epoch to the Jaramillo event from magnetic study. The study suggests that non-deposition or erosion has occurred after the Jaramillo, and this seems to be supported by the results of seismic reflection survey. The result is likely consistent with the conclusion of MATSUBAYASHI and MIZUNO (this cruise report) that the Pacific Bottom Water flows to the North Tokelau Basin and its east vicinity at the present day, and such behavior may have been strengthened during the time from the Jaramillo. through the recent, or after the Jaramillo.

St. 1609 is located in a small sediment pond with high relief of acoustic basement at the lower slope of the western flank of the Manihiki North Plateau. A weakly reflective layer of about 100 m thick lies on acoustic basement on the seismic reflection record. The obtained core represents the uppermost part of the layer.

### *Manihiki High Plateau and Danger Islands Trough*

Cores P164 and P163 were obtained from the Manihiki High Plateau and the Danger Islands Trough, respectively.

St. 1615 (P164) is located near DSDP Site 317. There the obtained core, 611 cm long, is entirely composed of calcareous ooze, i.e., very pale brown foram-nanno ooze (clayey in the top part) (0 to 2.1 m) and white to very pale brown nanno ooze (2.1 to 6.11 m). Micropaleontologic studies suggest that the upper part is the upper Quaternary (N23) and the lower part is the lower Pliocene (N19). This is in good agreement with the result of paleomagnetic study, and indicates a sedimentary hiatus from the late Pliocene to the early-middle Quaternary, despite that continuous sedimentation of calcareous ooze was described by the result of the deep-sea drilling (SCHLANGER, JACKSON, *et al.*, 1976) at DSDP Site 317. The cored sediment represents the uppermost part of late Eocene to Quaternary sequence of about 100 m thick according to our seismic reflection profile.

Core P163 (St. 1612) from the Danger Islands Trough consists of dark reddish brown calcareous mud (0 to 0.9 m) and very pale brown nanno ooze (clayey) (0.9 to the bottom). Although detailed aspect is still uncertain, the core shows a sedimentation during the late Pliocene to the Quaternary, according to the micropaleontologic data. The data indicate that the pilot core is of the late Quaternary but a depth of 54 cm (from the top) of the main core is dated the early Pleistocene. In this case, it might be expected that the uppermost part of the core is a product of decreased sedimentation rate. The calcareous mud rests on the underlying nanno ooze with a sharp boundary accompanied by rind burrows penetrated into the uppermost part of the ooze. This possibly indicates the presence of minor hiatus between the both facies. Also suggested is an abrupt decrease of CCD after the possible hiatus. Our seismic reflection profile shows that the trough is filled with sediments of about 500 m thick which abut against steep flanks of both sides of the trough. Although the sediment cored from their uppermost part has no sign of turbidite, the profile suggests the sediment-fill of dominantly turbidite nature, as discussed by WINTERER *et al.* (1974).

### *Manihiki Eastern Plateaus*

Two cores obtained are characterized by calcareous nature, but the detailed feature is very different to each other.

P168 (St. 1624) obtained from the acoustic transparent layer of about 70 m thick overlying a marked reflector (middle Eocene?) consists of very pale brown foram-nanno ooze (clayey), pale brown nanno-foram ooze (clayey), brown to dark brown foram-nanno ooze (clayey), white nanno ooze, and very pale brown nanno ooze, in descending order, with a thickness of 5.7 m in total. Although there is no appearance on the core and acoustic profile a large hiatus is present at a depth of ca. 1.1 m between the third and the fourth facies, according to the result of micropaleontologic study. The upper section composed of clayey foram-nanno or nanno-foram ooze is dated N23, whereas the lower one only composed of nanno ooze is assigned to the early Miocene.

P169 (St. 1626) consists, on the contrary, of repeated calcareous turbidite sequence of about 5.7 m thick, ranging from the early Pliocene to the Quaternary from micropaleontologic and paleomagnetic viewpoints. Four marked graded cycles are discriminated through the core. Each graded unit with a sharp contact with underlying sediment ranges from 40 to 80 cm in thickness and consists of basal foram ooze, overlaying nanno ooze, and siliceous (or radiolarian) calcareous mud in general (in ascending order). The lower part of the core consists of massive siliceous nanno marly ooze (3.9 to 4.5 m) and radiolarian mud (4.5 to 5.7 m) showing no turbidite structure. According to reflection seismic record, turbidite layers of 300 m thick are extensively developed in the environs of the present station, and the core represents their uppermost part.

### *Penrhyn Basin*

Two cores, P165 (St. 1618A) and P167 (St. 1622) from the Penrhyn Basin are characterized by zeolitic sediment. P167 only consists of zeolitic mud throughout. It is dark brown or dark reddish brown and without structure, whereas P165 comprizes dark reddish brown pelagic clay (0 to ca. 1 m) and very dusky red or reddish black zeolitic mud or zeolite rich clay of no structure (ca. 1 m to the bottom). Zeolitic mud in both cores includes phillipsites ranging from 15 to 25% in general. Data of their geologic age is still insufficient; that of P167 is unknown, but the upper part of P165 is possibly of the late Pliocene from the paleomagnetic evidence. Presence of the Quaternary sediment in the uppermost part of the core is still open, but even of any it may be very thin, possibly due to the influence of strengthened activity of bottom current through the Aitutaki Passage as suggested by PAUTOT and MELGUEN (1976). Both cores represent the upper part of thin un- or semi-consolidated sediments as deduced by seismic reflection survey.

Core P166 (St. 1619) consists of very dark brown zeolitic mud as well. With a 12 m long core tube, the corer penetrated into a depth of about 8 m beneath the sea floor. However, due to intense disturbance of obtained core, the detailed sequence of lithology is unknown, provided that a stiff pelagic clay interbed of about 5 cm thick likely occurs at a depth of approximately 1 m.

## Remarks on sedimentology along the Wake-Tahiti Transect

Figure V-6 presents the lithologic sequences of each cores with possible age designation arranged on the bathymetric profiles of two traverses. We can give the following summary of sedimentary history along the Wake-Tahiti Transect, based on the box- and piston core data, although there remain many unsolved problems particularly concerning age determination.

The cores obtained represent only the uppermost part of thick sedimentary sequence of the Eocene (?) to the Quaternary in most areas, except some limited cores which were taken from the areas where the sediment cover is very thin and the cores occupy its entire part (in the MPM area) or its upper half (in the MPM area, the PB, and the abyssal knoll area of the CPB). The basement rock obtained from the MPM area is hard chert (Eocene or earlier).

So far as the piston- and box core data are concerned, almost identical lithologic type of sediment has formed during the mid-late Tertiary or the Quaternary in nearly all areas with a few exceptions. Consequently the divided lithologic provinces for surface sediment distribution can be almost valid for the piston core lithologies. A narrow transitional belt between the equatorial siliceous biogenic and calcareous biogenic zones was doubtly deduced from the surface sediment data. It seems to appear much more clearly

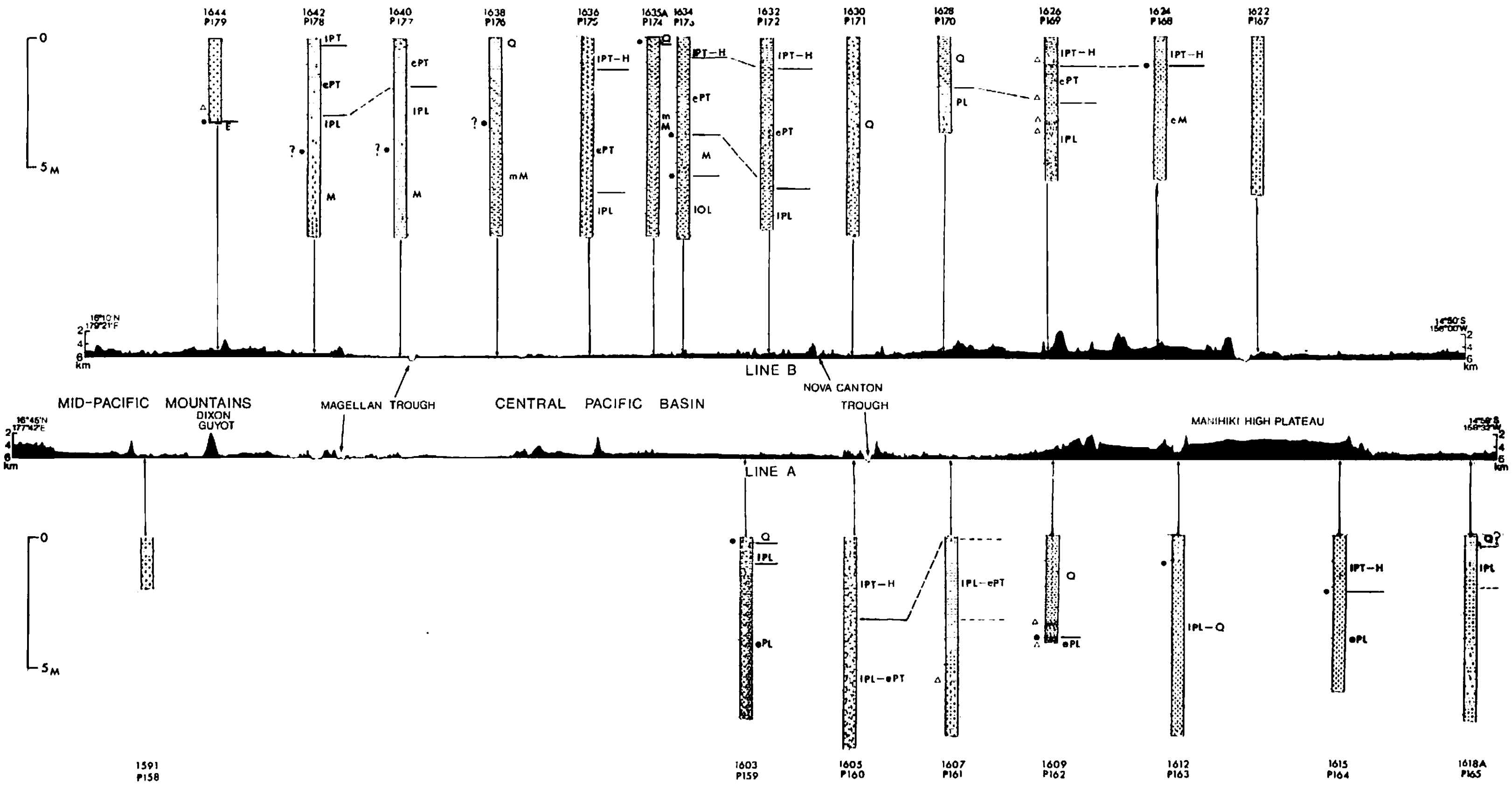

Fig. V-6 Lithologic sequence of piston cores plotted on bathymetric profiles, Lines A (lower) and B (upper). Abbreviations for geologic ages: H. Holocene, Pt. Pleistocene, Pl. Pliocene, M. Miocene, Ol. Oligocene, E. Eocene, l. late, m. middle, and e. early. Solid circles and open triangles indicate hiatuses and sedimentary structures caused by sediment gravity flows.

in the cores (P170 and P161) but under the style that pelagic clay dominantly deposited during the Pliocene or the early Pleistocene and the older age. This indicates that the abyssal sedimentation of siliceous materials had been quite asymmetric to the equator during the ages in consideration of reconstructed positions of the cores, as well as in the present day.

Vertical lithologic change is recognized in several piston cores. The cores from the transitional zone north and south of the equatorial siliceous biogenic zone show that the uppermost siliceous facies is underlain by pelagic clay. Their boundary seems to be diachronous, being around the boundary epoch of the early Pleistocene and the late Pleistocene, but in other cores up to the later or down to the earlier. The similar lithologic change was encountered in box cores. These facts may imply that siliceous plankton's productivity has been increased and extended areally in the youngest ages in general. Appearance of calcareous microfossils in the top part of core is found in some sites of the Central Pacific Basin. Calcareous plankton's high productivity zone may have extended during the late Pleistocene in general in the equatorial Central Pacific as well as the case of siliceous ones. Local, unexpectedly high productivity of calcareous planktons might have occurred during the late-latest Pliocene or earlier in part of the North Tokelau Basin (St. 1608).

On the contrary, decreasing of calcareous microfossils in the uppermost section of core is found in two cores from the Danger Islands Trough in the Manihiki Plateau (depth: ca. 4,800 m) and the Manihiki Eastern Plateaus (depth: ca. 3,900 m). This indicates a rising of CCD. It implies some relevant events. No evidence can be found, however, for the regional sea level rise and subsidence in the Central Pacific. Hence, either local subsidence, local change of water temperature, or local decrease of productivity of the organisms may have occurred in the age, but no conclusion can be given to this problem from the present data.

There are several evidences of reworking and redistribution of pre-existing sediments. They were encountered in the cores around the Manihiki Plateau (North Tokelau Basin, Manihiki Eastern Plateaus, and Manihiki Western Plateaus) as gravity flow deposits. Sedimentary structure probably of similar origin was also found in a core from a part of the MPM area, immediately above the bottom of entire sedimentary sequence. Seismic reflection records also show the extensive distribution of gravity flow deposits specifically around seamounts through geological ages.

Zeolitic sediments characterized by a lot of phillipsite grains are generally distributed in the MPM area and the PB. Also they can be found in the narrow transitional belt between the equatorial siliceous biogenic and calcareous biogenic zones. Their geologic age is still open in larger cases. Although not certain, the zeolitic sediments may be of the pre-Quaternary, with phillipsites originated from ancient volcanic materials.

Deep-sea hiatuses can be found in many places along the transect. Continuous sedimentation in steady rate (3.82 mm/1000 years) during the late Pliocene and the Quaternary was found in a part of the CPB (equatorial siliceous biogenic zone). However, nearly all the cores dated micropaleontologically and/or magnetically include possible hiatuses within, or much or less shortened Quaternary interval as suggested by SAITO *et al.* (1974).

Hiatuses occur in various ages. Middle to late Miocene and Pliocene sediments are missing in one core from the Manihiki Eastern Plateaus (P168); the interval and also the latest Oligocene to earliest Miocene sediments are missing in abyssal knoll area in the CPB (P173); another core from the abyssal knoll area shows a great hiatus between the middle Miocene and the Quaternary; even in deep-sea basin area of the CPB which is filled with siliceous sediments a possible hiatus is present between the late Pliocene and the Quaternary (?) (P176); and a hiatus between the Pliocene and the Quaternary or within the Quaternary are present in the cores from the Manihiki Plateau area (P162, P163, and P164).

Drastically shortened interval of the late Pleistocene to the Holocene was found in cores P178 and P177 from the northern CPB and P175 from the central CPB, and that of the entire Quaternary in cores P172, P173, P174, and P172 from the central CPB and P165 from the PB. It may be unlikely that the thinned sequence of younger ages in the CPB has been caused by the present day erosion under the environment of very slow northery movement of bottom water (MATSUBAYASHI and MIZUNO, this cruise report) or by localized drop of generally high biologic productivity the ages. It must have been related to intermittently strengthened bottom current during the Pleistocene, which may have given a strong influence as non-deposition or erosion to the bottom of the CPB selectively but rather extensively (NORMARK and SPIESS, 1976).

We can find a similar situation in the PB of the southern extremity of the transect. Bottom potential temperature suggests a weakened current flow from the north, if present, in the PB area observed (MATSUBAYASHI and MIZUNO, this cruise report), and an erosion in the present day may be not expected. However, the data of the PB core strongly indicates very thin Quaternary sediment if any, and this may have been caused by non-deposition and/or erosion during or at some time of the Quaternary which may have been related to low biologic productivity and/or the northery influx of cold current of the PBW originated from the AABW through the Aitutaki Passage (PAUTOT and MELGUEN, 1976). The shortened Quaternary interval in the cores from the Manihiki Eastern Plateaus may have also resulted from the similar process, located on the immediately northwest of the PB.

It is very likely that the PBW diversifies toward the North Tokelau Basin at the west of Manihiki Plateau and flows toward the east along the southern peripheral ridges of the Nova-Canton Trough at the present day (MATSUBAYASHI and MIZUNO, this cruise report). The thin late Pleistocene and Holocene sediments may owe to non-deposition or erosion under the current intensified during the times or markedly decreased biological productivity. The similar thin sequence found in the MPM area and the northern CPB (P178 and P177) could have been caused by very poor biological activity and/or the possible strong bottom current clockwisely diversified from the western boundary current of the Central Pacific, which had been much more strengthened than the present day but possibly fundamentally similar to the present status of the PBW distribution (LONSDALE, 1981).

## Summary

The surface sediment data from box cores and freefall grab samples suggest that the transect is divided into the following sedimentary provinces; northern pelagic clay zone, transitional zone, equatorial siliceous biogenic zone, equatorial calcareous biogenic zone, and southen pelagic zone, from north to south. Such zonal arrangement of lithology seems to be valid for mid-Tertiary to Quaternary sediment cores as evidenced micropaleontologically and/or magnetically, except for some sites particularly in the transitional zone. A very narrow transitional zone is established in-between the equatorial siliceous and calcareous biogenic zones on the basis of piston core lithology. Those indicate that the sedimentation has been controlled by almost identical aspects of bathymetry, biologic productivity, volcanism, supply of terrigenous materials, etc. in respective provinces during the ages, except for the transitional zones. In cores from seamount and plateau areas and their vicinity sedimentary structures suggestive of resedimentation or redistribution of sediments are developed. Deepsea hiatuses occur extensively in various geologic ages. Very shortened interval of the entire Quaternary or the late Pleistocene to Recent also occur extensively. The both can be recognized not only in topographic highs but also in abyssal basins. Those may have resulted from much decreased biologic productivity and/or much more marked bottom currents through the mid-Tertiary to Quaternary in respective areas.

From the genetical viewpoint of manganese nodules the followings are noted. Small manganese nodules of s-type occur just above the hiatuses in core P173. Perhaps the hiatuses may have contributed to the genesis of those nodules as well as the case in the Samoan Passage core (HOLLSTER *et al.*, 1974). We can observe in core P176 an example to show possible biogenic reduction of sediment and consequent dissolution of metal oxides such as manganate specks and reprecipitation of the metal element in the surrounding parts of a burrow as demonstrated by HARTMANN (1979). Regional distribution of manganese nodule types is closely related to that of the surface sediment types, hence to that of core lithologies through the Tertiary to the Quaternary (see Chap. VII, this cruise report). This suggests that the nodule growth has been influenced by sedimentation rate, activity of bottom current, biological activity, volcanic activity, etc. through the geological ages. Particular correlation can not be found among Local variabilities of nodule abundance, metal grade, type, and sediment sequence in relation to hiatuses as described by MIZUNO (1981), except for a small area on and around a abyssal knoll in the central CPB (St. 1635A) where the relation between nodule type and sedimentary sequence of the Quaternary, is recognized.

## Acknowledgements

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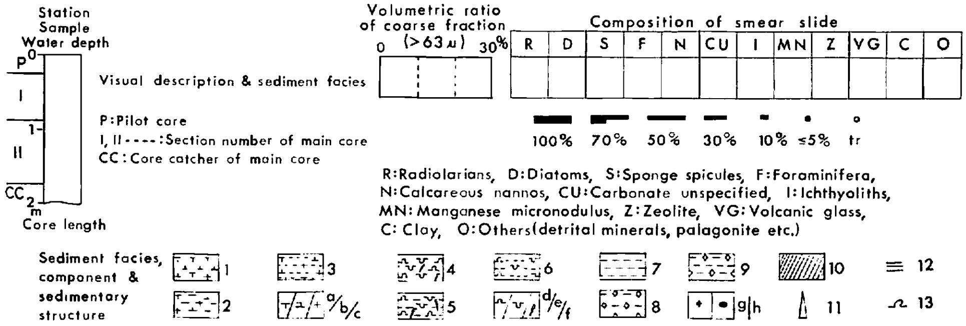
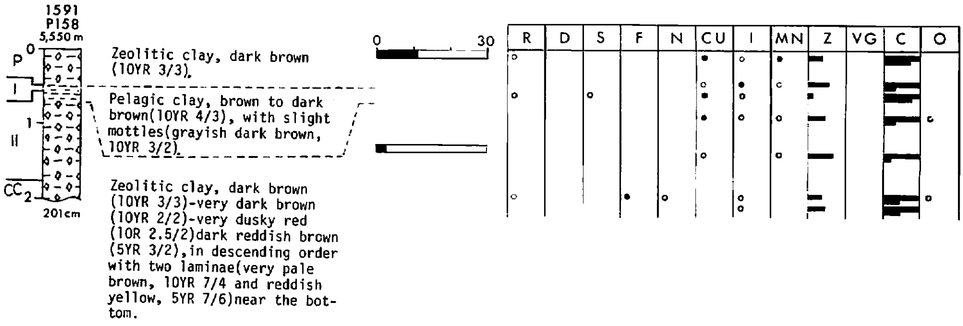


P:Pilot core
I, II----:Section number of main core
CC:Core catcher of main core

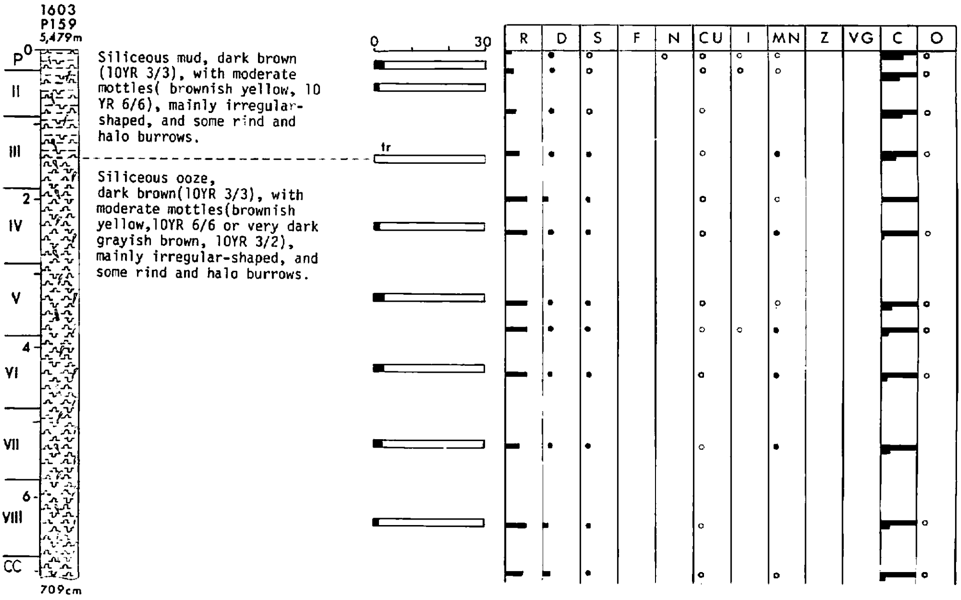
R:Radiolarians, D:Diatoms, S:Sponge spicules, F:Foraminifera, N:Calcareous nannos, CU:Carbonate unspecified, I:Ichthyoliths, MN:Manganese micronodulus, Z:Zeolite, VG:Volcanic glass, C:Clay, O:Others(detrital minerals, palagonite etc.)



Zeolitic clay, dark brown (10YR 3/3).

Pelagic clay, brown to dark brown(10YR 4/3), with slight mottles(grayish dark brown, 10YR 3/2).

Zeolitic clay, dark brown (10YR 3/3)-very dark brown (10YR 2/2)-very dusky red (10R 2.5/2)dark reddish brown (5YR 3/2),in descending order with two laminae(very pale brown, 10YR 7/4 and reddish yellow, 5YR 7/6)near the bottom.

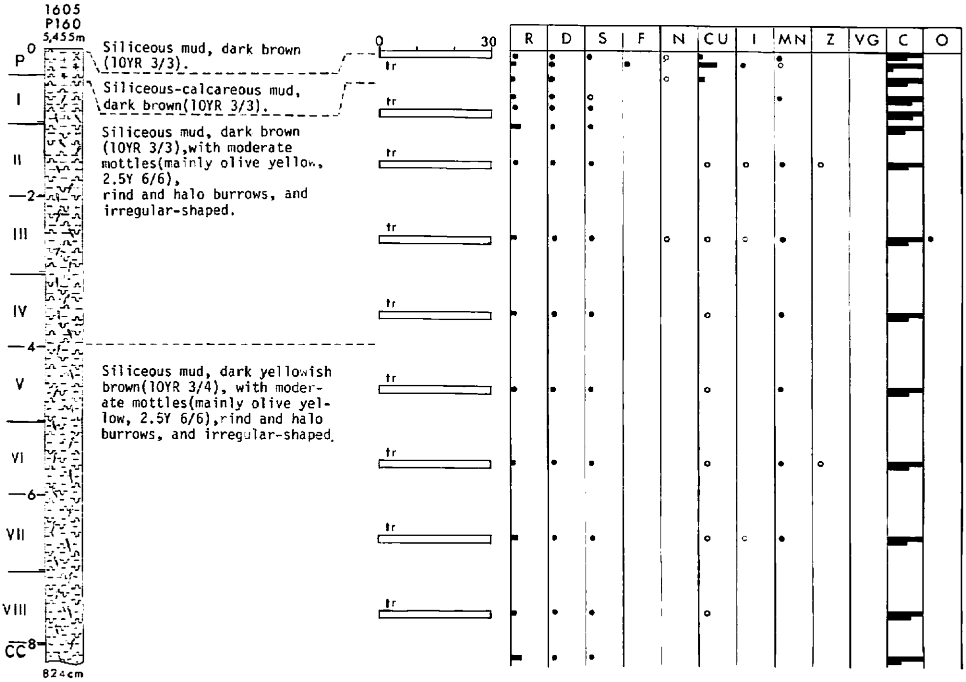


Siliceous mud, dark brown (10YR 3/3), with moderate mottles( brownish yellow, 10 YR 6/6), mainly irregular-shaped, and some rind and halo burrows.

Siliceous ooze, dark brown(10YR 3/3), with moderate mottles(brownish yellow,10YR 6/6 or very dark grayish brown, 10YR 3/2), mainly irregular-shaped, and some rind and halo burrows.

(1)

Appendix V-1 Descriptions of individual core with microscopic composition of smear slides. Legend for lithology is common to V-4.

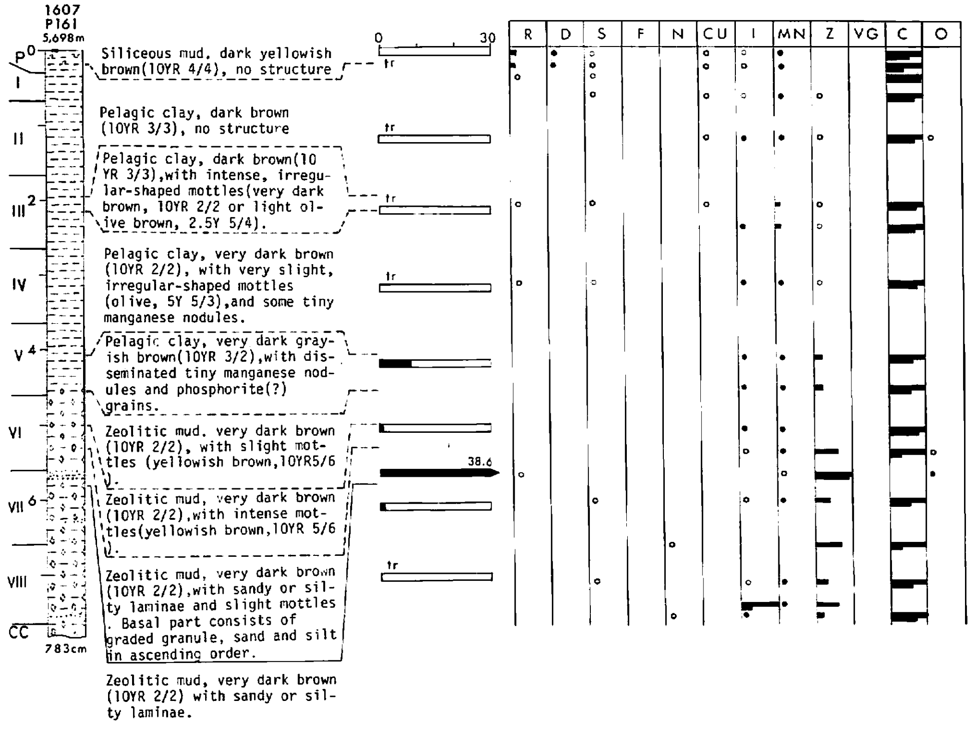


Siliceous mud, dark brown (10YR 3/3).

Siliceous-calcareous mud, dark brown(10YR 3/3).

Siliceous mud, dark brown (10YR 3/3),with moderate mottles(mainly olive yellow, 2.5Y 6/6), rind and halo burrows, and irregular-shaped.

Siliceous mud, dark yellowish brown(10YR 3/4), with moderate mottles(mainly olive yellow, 2.5Y 6/6),rind and halo burrows, and irregular-shaped.



Siliceous mud, dark yellowish brown(10YR 4/4), no structure

Pelagic clay, dark brown (10YR 3/3), no structure

Pelagic clay, dark brown(10 YR 3/3),with intense, irregular-shaped mottles(very dark brown, 10YR 2/2 or light olive brown, 2.5Y 5/4).

Pelagic clay, very dark brown (10YR 2/2), with very slight, irregular-shaped mottles (olive, 5Y 5/3),and some tiny manganese nodules.

Pelagic clay, very dark grayish brown(10YR 3/2),with disseminated tiny manganese nodules and phosphorite(?) grains.

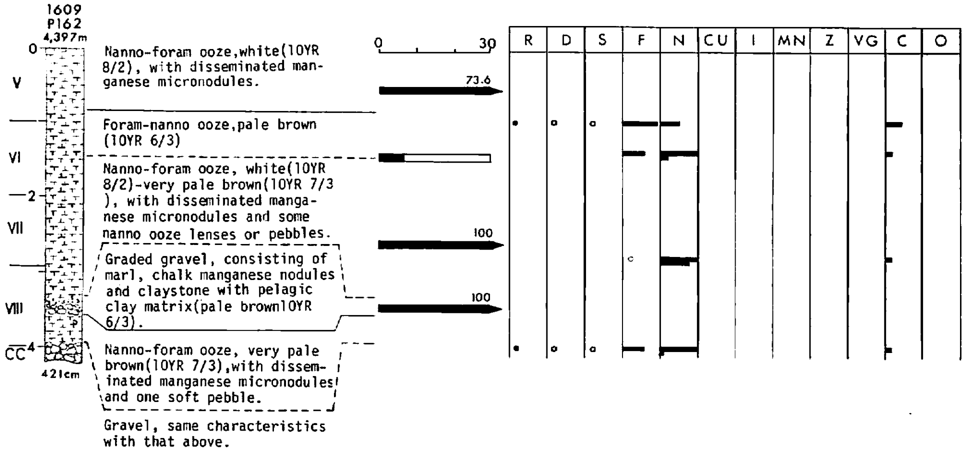
Zeolitic mud. very dark brown (10YR 2/2), with slight mottles (yellowish brown,10YR5/6 ).

Zeolitic mud, very dark brown (10YR 2/2),with intense mottles(yellowish brown,10YR 5/6 ).

Zeolitic mud, very dark brown (10YR 2/2),with sandy or silty laminae and slight mottles . Basal part consists of graded granule, sand and silt in ascending order.

Zeolitic mud, very dark brown (10YR 2/2) with sandy or silty laminae.

(2)



Nanno-foram ooze, white(10YR 8/2), with disseminated manganese micronodules.

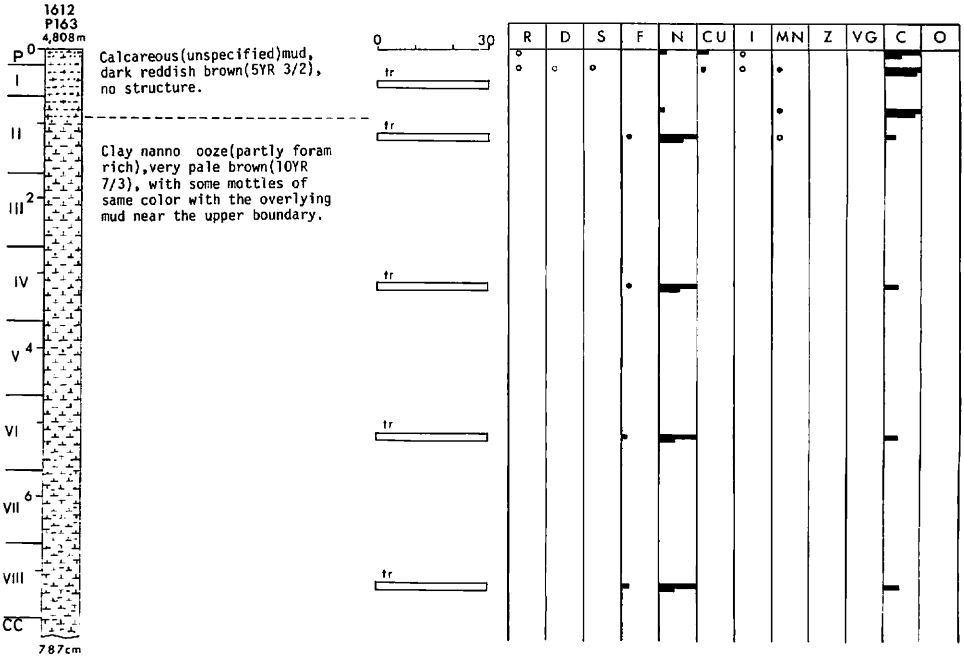
Foram-nanno ooze, pale brown (10YR 6/3)

Nanno-foram ooze, white(10YR 8/2)-very pale brown(10YR 7/3), with disseminated manganese micronodules and some nanno ooze lenses or pebbles.

Graded gravel, consisting of marl, chalk manganese nodules and claystone with pelagic clay matrix(pale brown10YR 6/3).

Nanno-foram ooze, very pale brown(10YR 7/3), with disseminated manganese micronodules and one soft pebble.

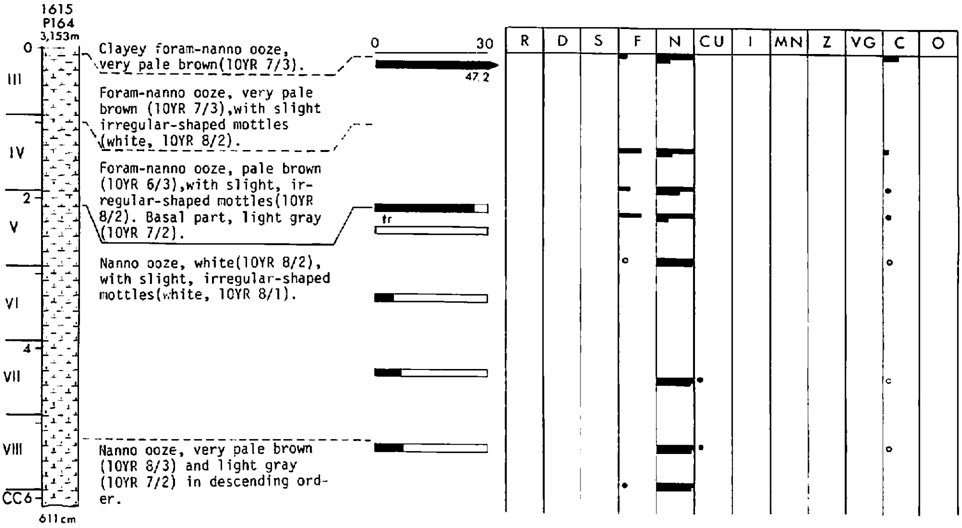
Gravel, same characteristics with that above.



Calcareous(unspecified)mud, dark reddish brown(5YR 3/2), no structure.

Clay nanno ooze(partly foram rich), very pale brown(10YR 7/3), with some mottles of same color with the overlying mud near the upper boundary.

(3)



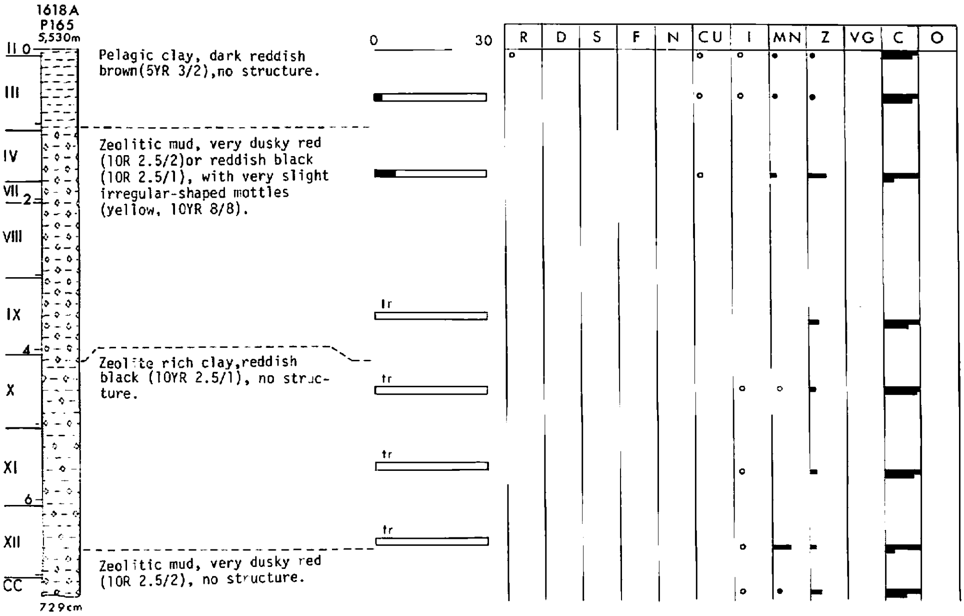
Clayey foram-nanno ooze, very pale brown(10YR 7/3).

Foram-nanno ooze, very pale brown (10YR 7/3),with slight irregular-shaped mottles (white, 10YR 8/2).

Foram-nanno ooze, pale brown (10YR 6/3),with slight, irregular-shaped mottles(10YR 8/2). Basal part, light gray (10YR 7/2).

Nanno ooze, white(10YR 8/2), with slight, irregular-shaped mottles(white, 10YR 8/1).

Nanno ooze, very pale brown (10YR 8/3) and light gray (10YR 7/2) in descending order.



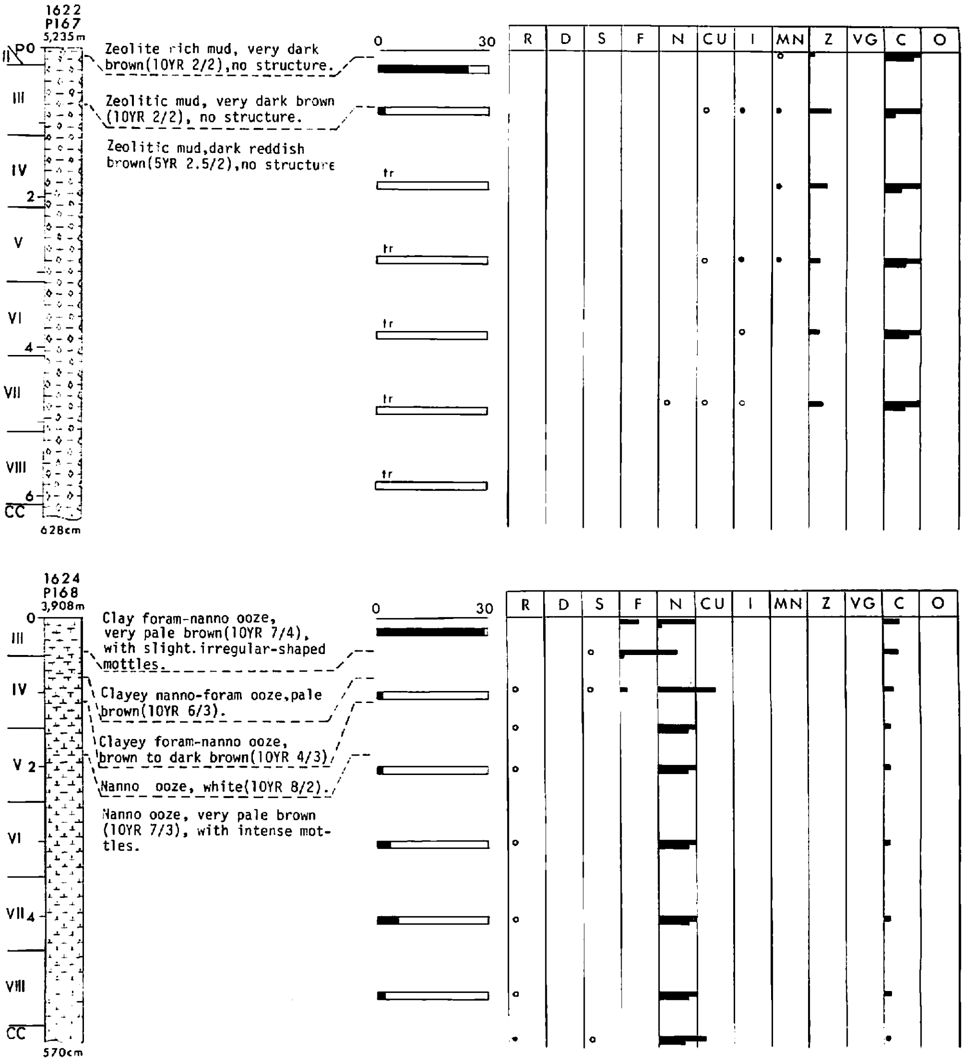
Pelagic clay, dark reddish brown(5YR 3/2),no structure.

Zeolitic mud, very dusky red (10R 2.5/2)or reddish black (10R 2.5/1), with very slight irregular-shaped mottles (yellow, 10YR 8/8).

Zeolite rich clay,reddish black (10YR 2.5/1), no structure.

Zeolitic mud, very dusky red (10R 2.5/2), no structure.

(4)


1622
P167
5,235m
0
2
4
6
628cm
PO
II
III
IV
V
VI
VII
VIII
CC
Zeolite rich mud, very dark brown(10YR 2/2),no structure.
Zeolitic mud, very dark brown (10YR 2/2), no structure.
Zeolitic mud,dark reddish brown(5YR 2.5/2),no structure
0
30
tr
R
D
S
F
N
CU
I
MN
Z
VG
C
O
1624
P168
3,908m
0
2
4
570cm
III
IV
V
VI
VII
VIII
CC
Clay foram-nanno ooze, very pale brown(10YR 7/4), with slight.irregular-shaped mottles.
Clayey nanno-foram ooze,pale brown(10YR 6/3).
Clayey foram-nanno ooze, brown to dark brown(10YR 4/3).
Nanno ooze, white(10YR 8/2).
Nanno ooze, very pale brown (10YR 7/3), with intense mottles.
0
30
R
D
S
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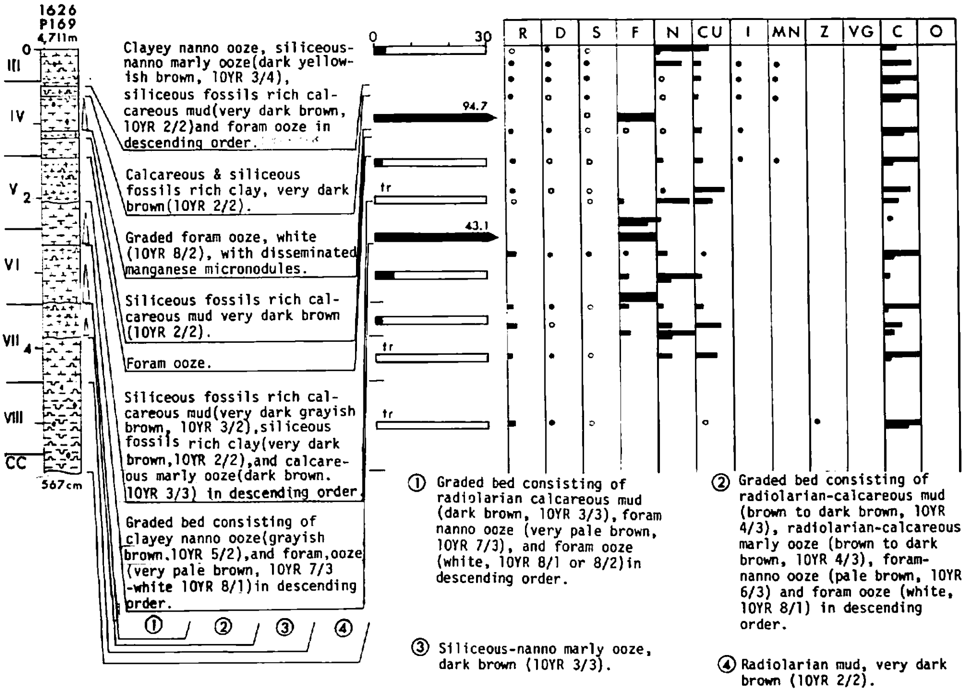
O

(5)



Clayey nanno ooze, siliceous-nanno marly ooze(dark yellowish brown, 10YR 3/4), siliceous fossils rich calcareous mud(very dark brown, 10YR 2/2)and foram ooze in descending order.

Calcareous & siliceous fossils rich clay, very dark brown(10YR 2/2).

Graded foram ooze, white (10YR 8/2), with disseminated manganese micronodules.

Siliceous fossils rich calcareous mud very dark brown (10YR 2/2).

Foram ooze.

Siliceous fossils rich calcareous mud(very dark grayish brown, 10YR 3/2),siliceous fossils rich clay(very dark brown,10YR 2/2),and calcareous marly ooze(dark brown. 10YR 3/3) in descending order.

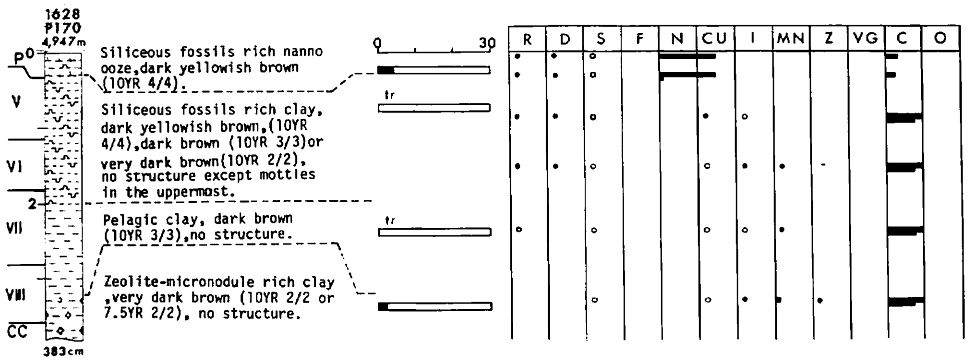
Graded bed consisting of clayey nanno ooze(grayish brown.10YR 5/2),and foram,ooze (very pale brown, 10YR 7/3 -white 10YR 8/1)in descending order.

① Graded bed consisting of radiolarian calcareous mud (dark brown, 10YR 3/3), foram nanno ooze (very pale brown, 10YR 7/3), and foram ooze (white, 10YR 8/1 or 8/2)in descending order.

② Graded bed consisting of radiolarian-calcareous mud (brown to dark brown, 10YR 4/3), radiolarian-calcareous marly ooze (brown to dark brown, 10YR 4/3), foram-nanno ooze (pale brown, 10YR 6/3) and foram ooze (white, 10YR 8/1) in descending order.

③ Siliceous-nanno marly ooze, dark brown (10YR 3/3).

④ Radiolarian mud, very dark brown (10YR 2/2).



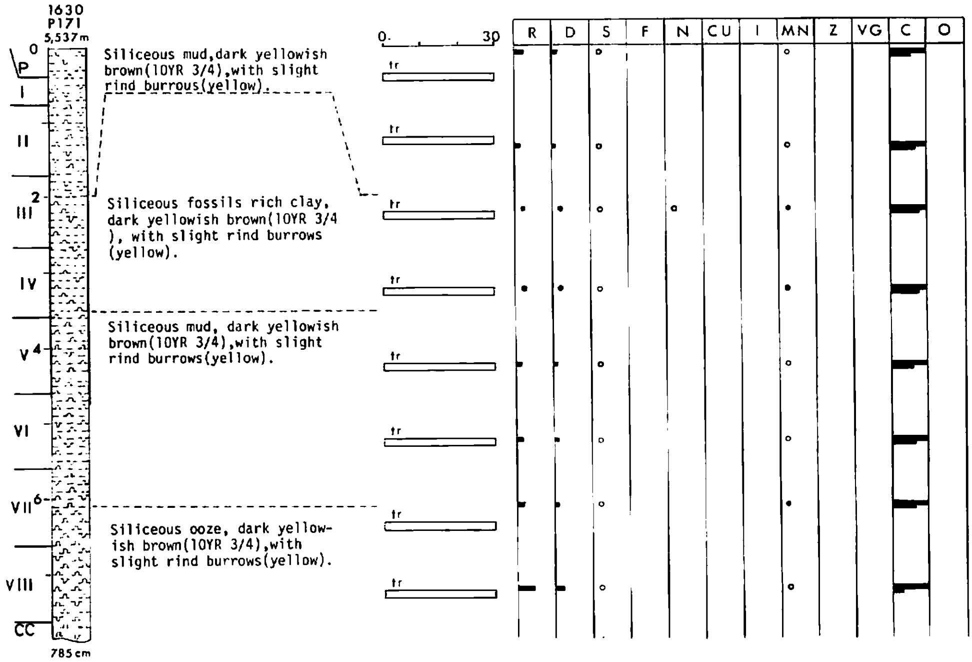
Siliceous fossils rich nanno ooze,dark yellowish brown (10YR 4/4).

Siliceous fossils rich clay, dark yellowish brown,(10YR 4/4),dark brown (10YR 3/3)or very dark brown(10YR 2/2), no structure except mottles in the uppermost.

Pelagic clay, dark brown (10YR 3/3),no structure.

Zeolite-micronodule rich clay ,very dark brown (10YR 2/2 or 7.5YR 2/2), no structure.

(6)

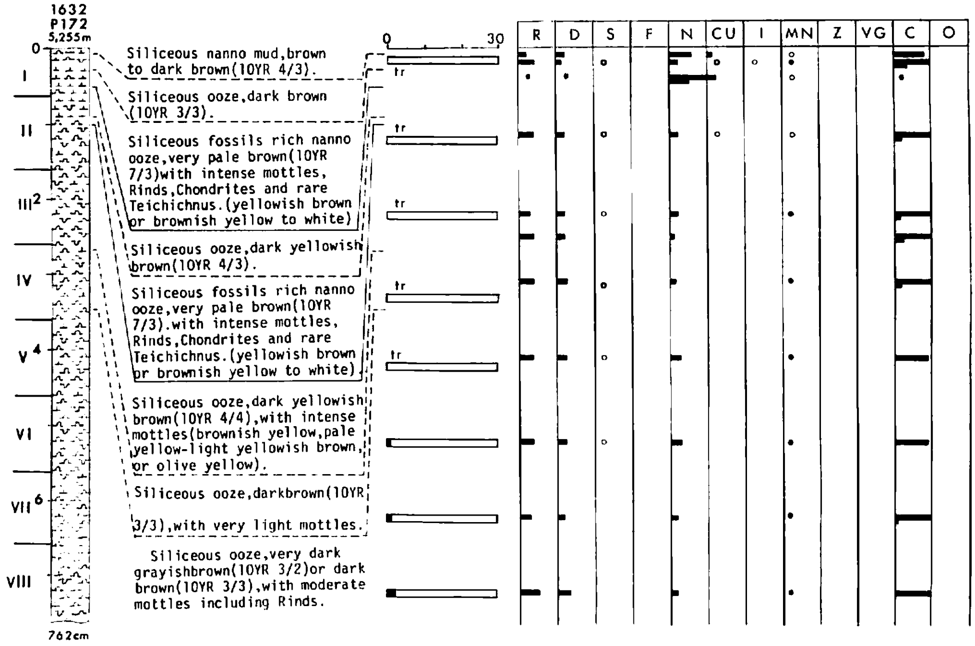


Siliceous mud,dark yellowish brown(10YR 3/4),with slight rind burrous(yellow).

Siliceous fossils rich clay, dark yellowish brown(10YR 3/4), with slight rind burrows (yellow).

Siliceous mud, dark yellowish brown(10YR 3/4),with slight rind burrows(yellow).

Siliceous ooze, dark yellowish brown(10YR 3/4),with slight rind burrows(yellow).



Siliceous nanno mud,brown to dark brown(10YR 4/3).

Siliceous ooze,dark brown (10YR 3/3).

Siliceous fossils rich nanno ooze,very pale brown(10YR 7/3)with intense mottles, Rinds,Chondrites and rare Teichichnus.(yellowish brown or brownish yellow to white)

Siliceous ooze,dark yellowish brown(10YR 4/3).

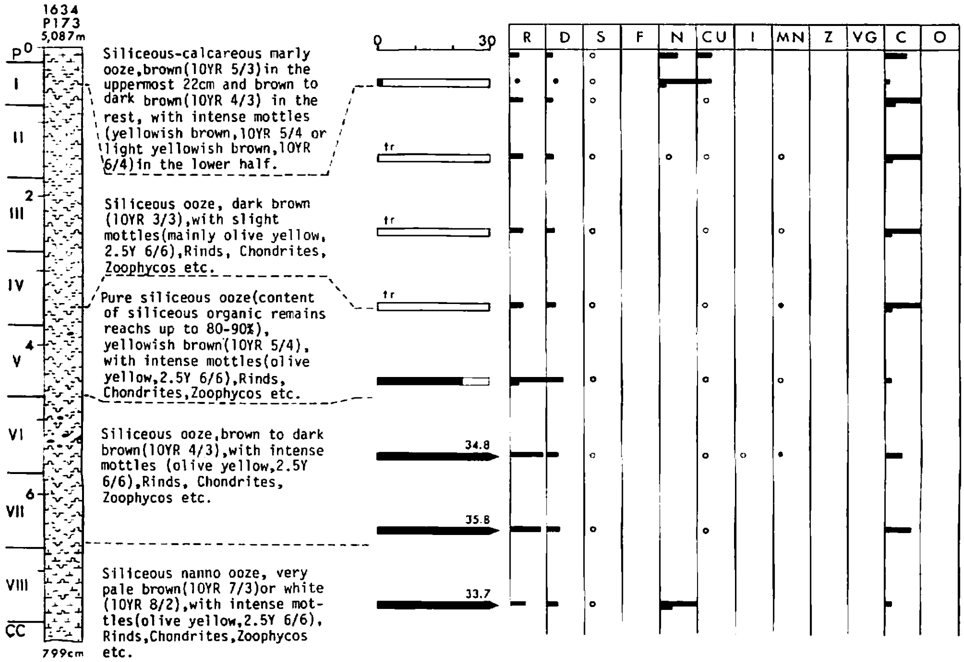
Siliceous fossils rich nanno ooze,very pale brown(10YR 7/3).with intense mottles, Rinds,Chondrites and rare Teichichnus.(yellowish brown or brownish yellow to white)

Siliceous ooze,dark yellowish brown(10YR 4/4),with intense mottles(brownish yellow,pale yellow-light yellowish brown, or olive yellow).

Siliceous ooze,darkbrown(10YR 3/3),with very light mottles.

Siliceous ooze,very dark grayishbrown(10YR 3/2)or dark brown(10YR 3/3),with moderate mottles including Rinds.

(7)



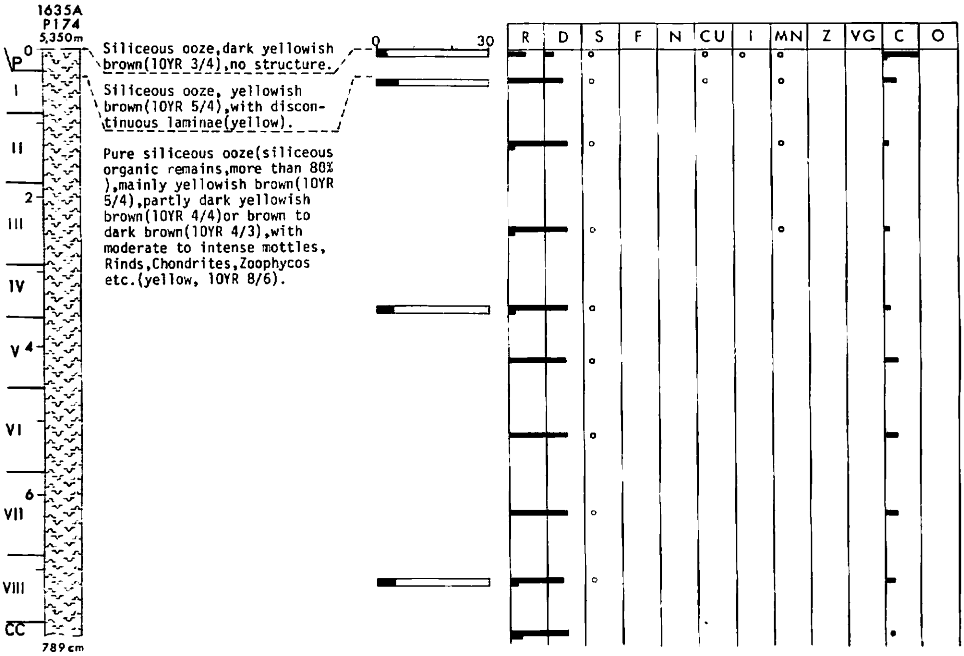
Siliceous-calcareous marly ooze, brown(10YR 5/3) in the uppermost 22cm and brown to dark brown(10YR 4/3) in the rest, with intense mottles (yellowish brown, 10YR 5/4 or light yellowish brown, 10YR 6/4) in the lower half.

Siliceous ooze, dark brown (10YR 3/3), with slight mottles(mainly olive yellow, 2.5Y 6/6), Rinds, Chondrites, Zoophycos etc.

Pure siliceous ooze(content of siliceous organic remains reachs up to 80-90%), yellowish brown(10YR 5/4), with intense mottles(olive yellow, 2.5Y 6/6), Rinds, Chondrites, Zoophycos etc.

Siliceous ooze, brown to dark brown(10YR 4/3), with intense mottles (olive yellow, 2.5Y 6/6), Rinds, Chondrites, Zoophycos etc.

Siliceous nanno ooze, very pale brown(10YR 7/3) or white (10YR 8/2), with intense mottles(olive yellow, 2.5Y 6/6), Rinds, Chondrites, Zoophycos etc.

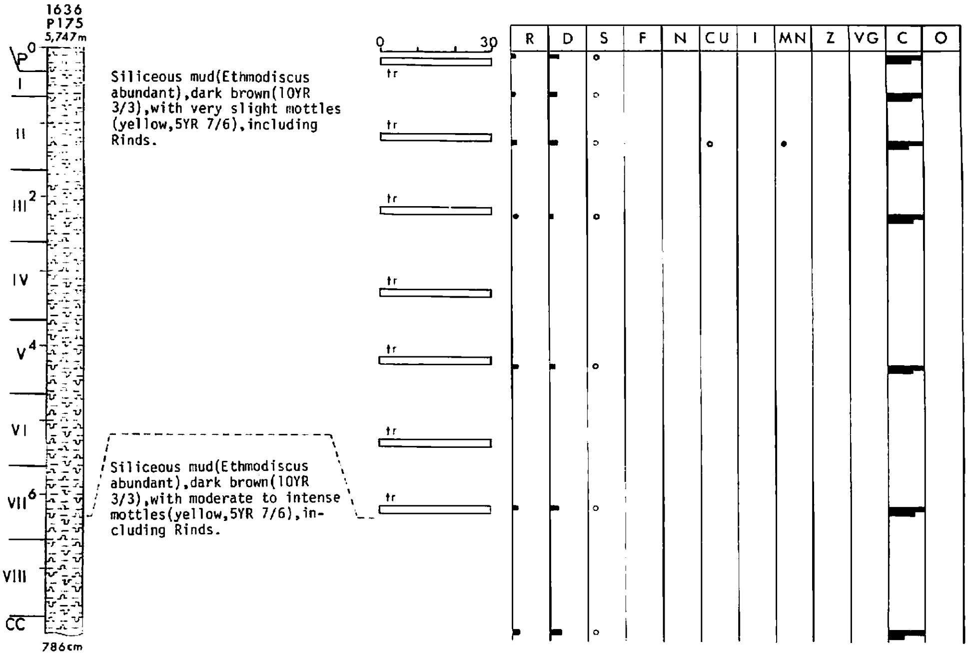


Siliceous ooze, dark yellowish brown(10YR 3/4), no structure.

Siliceous ooze, yellowish brown(10YR 5/4), with discontinuous laminae(yellow).

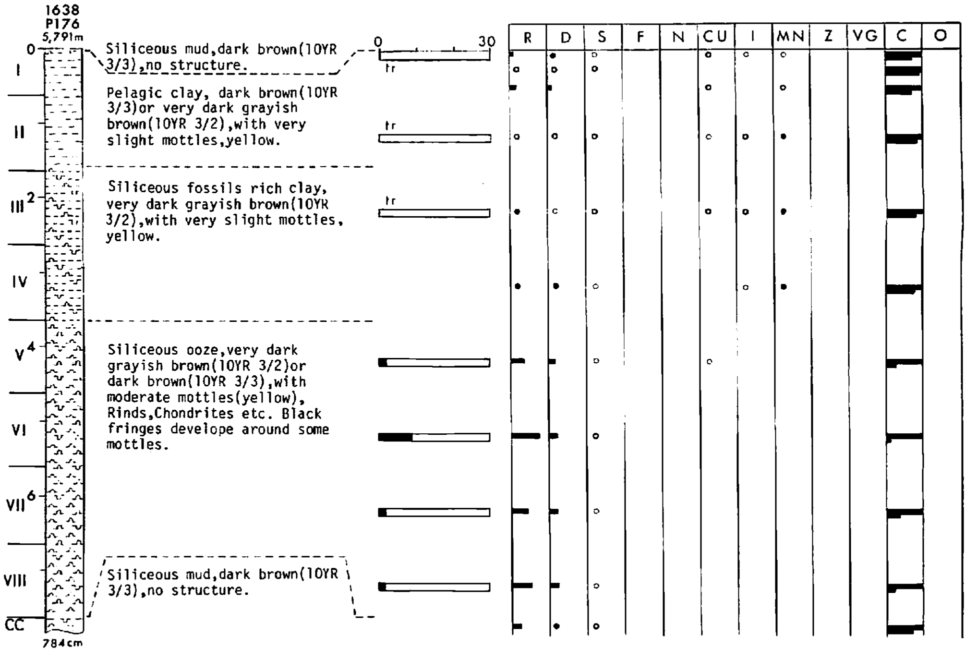
Pure siliceous ooze(siliceous organic remains, more than 80%), mainly yellowish brown(10YR 5/4), partly dark yellowish brown(10YR 4/4) or brown to dark brown(10YR 4/3), with moderate to intense mottles, Rinds, Chondrites, Zoophycos etc.(yellow, 10YR 8/6).

(8)



Siliceous mud(Ethmodiscus abundant),dark brown(10YR 3/3),with very slight mottles (yellow,5YR 7/6),including Rinds.

Siliceous mud(Ethmodiscus abundant),dark brown(10YR 3/3),with moderate to intense mottles(yellow,5YR 7/6),including Rinds.



Siliceous mud,dark brown(10YR 3/3),no structure.

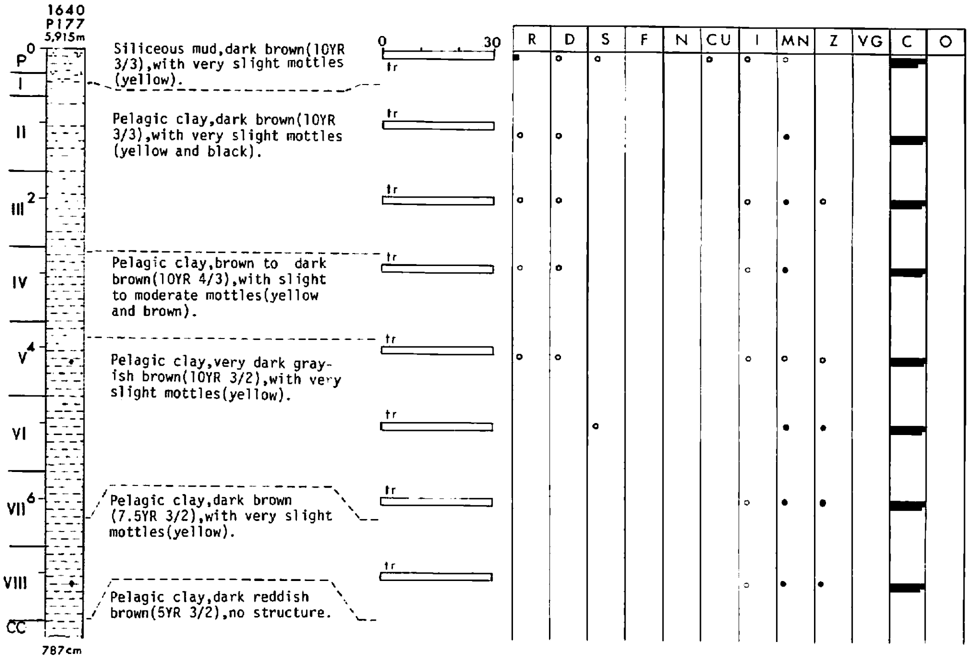
Pelagic clay, dark brown(10YR 3/3)or very dark grayish brown(10YR 3/2),with very slight mottles,yellow.

Siliceous fossils rich clay, very dark grayish brown(10YR 3/2),with very slight mottles, yellow.

Siliceous ooze,very dark grayish brown(10YR 3/2)or dark brown(10YR 3/3),with moderate mottles(yellow), Rinds,Chondrites etc. Black fringes develope around some mottles.

Siliceous mud,dark brown(10YR 3/3),no structure.

(9)



Siliceous mud, dark brown (10YR 3/3), with very slight mottles (yellow).

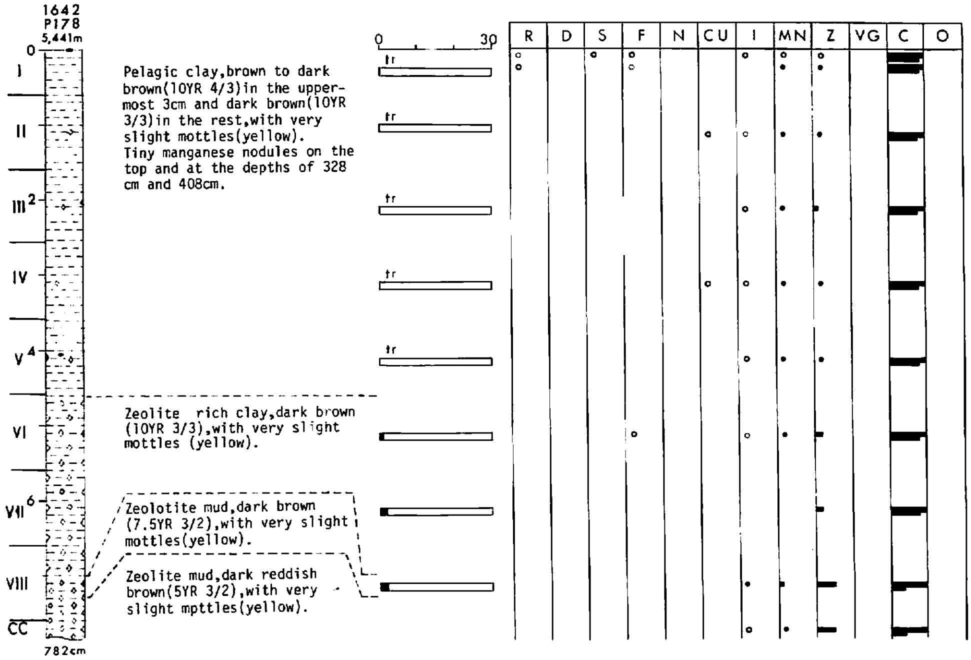
Pelagic clay, dark brown (10YR 3/3), with very slight mottles (yellow and black).

Pelagic clay, brown to dark brown (10YR 4/3), with slight to moderate mottles (yellow and brown).

Pelagic clay, very dark grayish brown (10YR 3/2), with very slight mottles (yellow).

Pelagic clay, dark brown (7.5YR 3/2), with very slight mottles (yellow).

Pelagic clay, dark reddish brown (5YR 3/2), no structure.

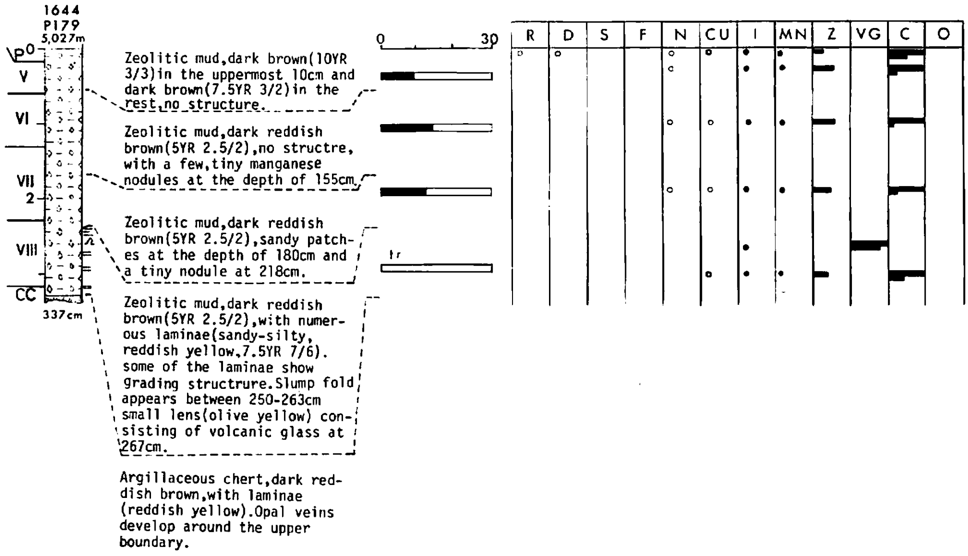


Pelagic clay, brown to dark brown (10YR 4/3) in the uppermost 3cm and dark brown (10YR 3/3) in the rest, with very slight mottles (yellow).
Tiny manganese nodules on the top and at the depths of 328 cm and 408cm.

Zeolite rich clay, dark brown (10YR 3/3), with very slight mottles (yellow).

Zeolotite mud, dark brown (7.5YR 3/2), with very slight mottles (yellow).

Zeolite mud, dark reddish brown (5YR 3/2), with very slight mpttles (yellow).



Zeolitic mud,dark brown(10YR 3/3)in the uppermost 10cm and dark brown(7.5YR 3/2)in the rest,no structure.

Zeolitic mud,dark reddish brown(5YR 2.5/2),no structre, with a few,tiny manganese nodules at the depth of 155cm.

Zeolitic mud,dark reddish brown(5YR 2.5/2),sandy patches at the depth of 180cm and a tiny nodule at 218cm.

Zeolitic mud,dark reddish brown(5YR 2.5/2),with numerous laminae(sandy-silty, reddish yellow,7.5YR 7/6). some of the laminae show grading structrure.Slump fold appears between 250-263cm small lens(olive yellow) consisting of volcanic glass at 267cm.

Argillaceous chert,dark reddish brown,with laminae (reddish yellow).Opal veins develop around the upper boundary.

(11)