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PART II

XI. PALEOMAGNETIC STRATIGRAPHY OF DEEP-SEA SEDIMENTS IN THE CENTRAL EQUATORIAL PACIFIC (GH81-4 AREA)

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Introduction

Paleomagnetic stratigraphy is one of the strong tools to clarify the sedimentation history of deep-sea sediments. Remanent magnetization of the deep-sea sediments obtained during the GH81-4 cruise was measured. Sediment cores were collected by a piston-corer of 8 m long at closely spaced thirteen sites in the Central Equatorial Pacific (Table XI-1). Topography of the study area consists of deep-sea hills of relative height of about 300 m and the surrounding flat basin of about 5,600 m in depth (Chapter I in this report). Samples are composed of mainly siliceous clay or siliceous ooze, partly pelagic clay, but no calcareous sediment was found because the water depth of this area is below the CCD (Carbonate Compensation Depth) presented at 5,000 m in depth (BERGER and WINTERER, 1974). It is known that siliceous sediments have stable remanent magnetization (OPDYKE *et al.*, 1966; OPDYKE and FOSTER, 1970) and are suitable for study of paleomagnetic stratigraphy.

Measurement

A series of specimens for paleomagnetic measurements were taken on board from split cores with small cubic cases of about 7 cm^3 each. Specimens were carefully sealed for the prevention of the decay of DRM (Depositional Remanent Magnetization) due to the effect of drying (OTOFUJI *et al.*, 1982). Soon after the cruise (one or two months after the sampling) measurements were carried out using a cryogenic rock magnetometer (SCT model C113). As a general rule every third specimen (about 7 cm interval) was measured, but the specimens which lay near the polarity boundary or in the weakly and/or unstably magnetized portion were continuously measured. Alternating Field (AF) demagnetization by a three-axis tumbler system was carried out to erase unstable secondary magnetization. To determine the peak field of routine AF demagnetization which should remove the secondary magnetization most effectively, the coercivity of the remanence of several pilot specimens per each core was examined by stepwise AF demagnetization. As a result, a field of 7.5 or 10 mT was adopted. Except for a few cores, the sediments were slightly overprinted by the secondary magnetization.

As sediment cores are not oriented horizontally as usual, the inclination data are generally used to determine their polarity. In the equatorial region including the study area, however, the polarity must be determined in a different way because the inclination closes to zero. I could determine the polarity based on the behavior of the intensity of the remanent magnetization during stepwise AF demagnetization. An example is shown in Fig. XI-1. During the stepwise AF demagnetization the specimens of reversed polarity showed a temporary increase in the intensity of the remanent

Table XI-1 Location of the sediment cores in the GH81-4 area.

Core No.	Latitude (N)	Longitude (W)	Depth (m)
P218	3°19.86'	169°35.06'	5473
P219	3°10.57'	169°44.69'	5578
P220	3°15.30'	169°40.79'	5371
P221	3°07.54'	169°27.57'	5538
P222	2°57.39'	169°38.05'	5584
P223	3°02.32'	169°31.94'	5309
P224	3°16.64'	169°41.07'	5500
P225	3°13.32'	169°41.65'	5427
P226	2°53.08'	169°34.86'	5547
P227	2°49.81'	169°38.42'	5355
P228	2°49.29'	169°41.20'	5568
P229	2°46.16'	169°40.25'	5646
P230	3°13.38'	169°35.66'	5600

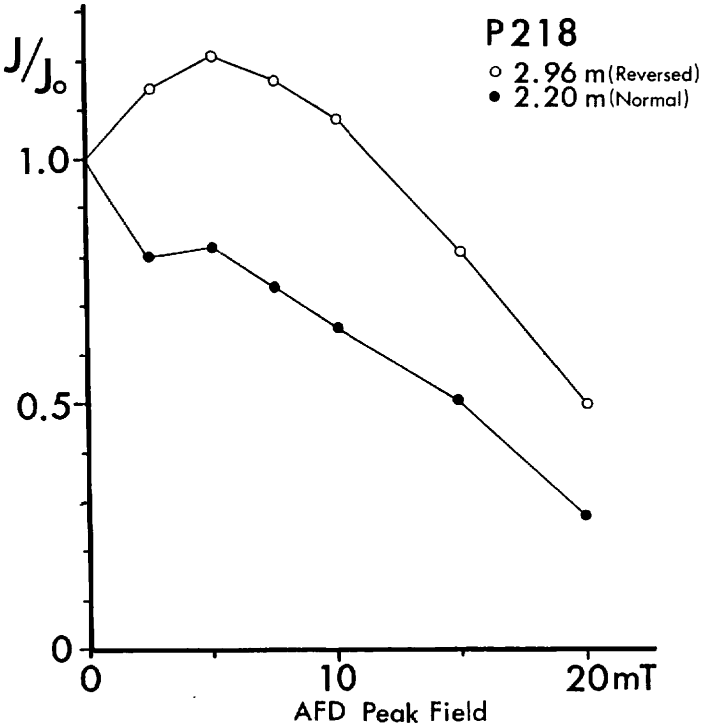

Fig. XI-1 A typical response of the intensity of remanent magnetization to stepwise AF demagnetization (ratio to the intensity before the demagnetization). The reversed specimen showed a temporary increase in the intensity by the low demagnetizing fields.

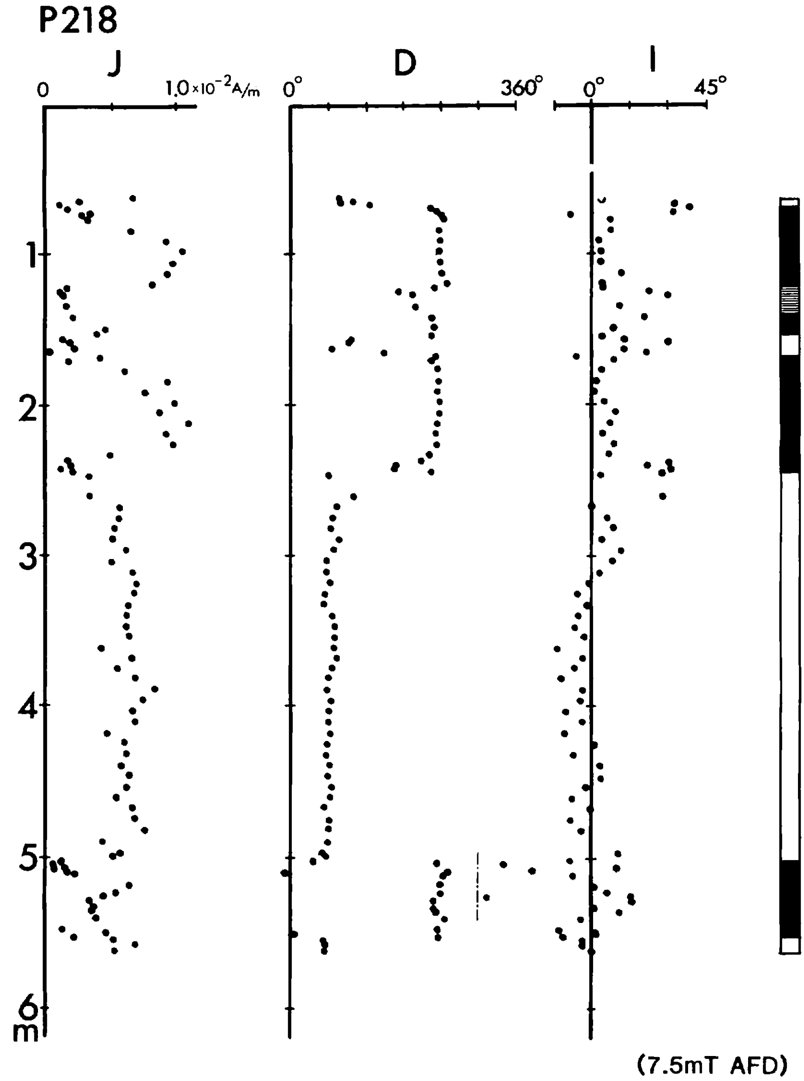

Fig. XI-2(1)

Fig. XI-2(1)-(13) Intensity (J), relative declination (D) and inclination (I) of remanent magnetization after the magnetic cleaning by alternating field demagnetization. Right column shows the polarity of the magnetization (Solid bar represents normaly magnetized part, open does reversed).

magnetization by the low demagnetizing fields (less than 10 mT) due to the removal of a soft secondary component of the present geomagnetic field direction which is opposed to the direction of the primary remanence. In some cases the polarity in the uppermost part of a core is proved to be of the Brunhes Normal Epoch based on siliceous microfossils.

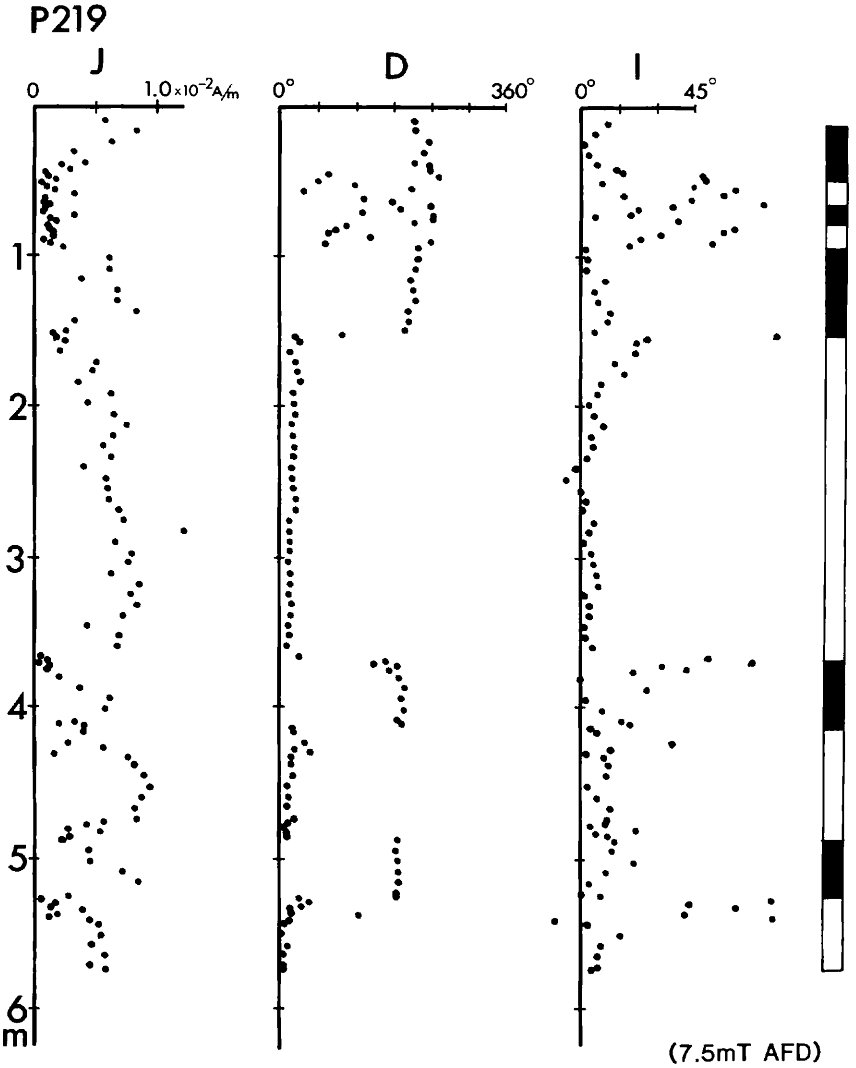

Fig. XI-2(2)

Results and discussion

Figure XI-2 shows the direction, the intensity and the polarity of the remanent magnetization of each core after the magnetic cleaning by AF demagnetization. Paleomagnetic polarity sequences, lithology, some horizons of microfossils and estimated ages are summarized in Fig. XI-3. Descriptions of core lithology and microfossils are given by A. NISHIMURA (Chapter VI in this report). The geomagnetic polarity time scale of BERGGREN *et al.* (1985) is adopted in the following discussion.

Age assignments

Cores P221, P222, P226, P228, P229 and P230 show the polarity sequences which are in good correlation with the standard one of the Brunhes and the Matuyama

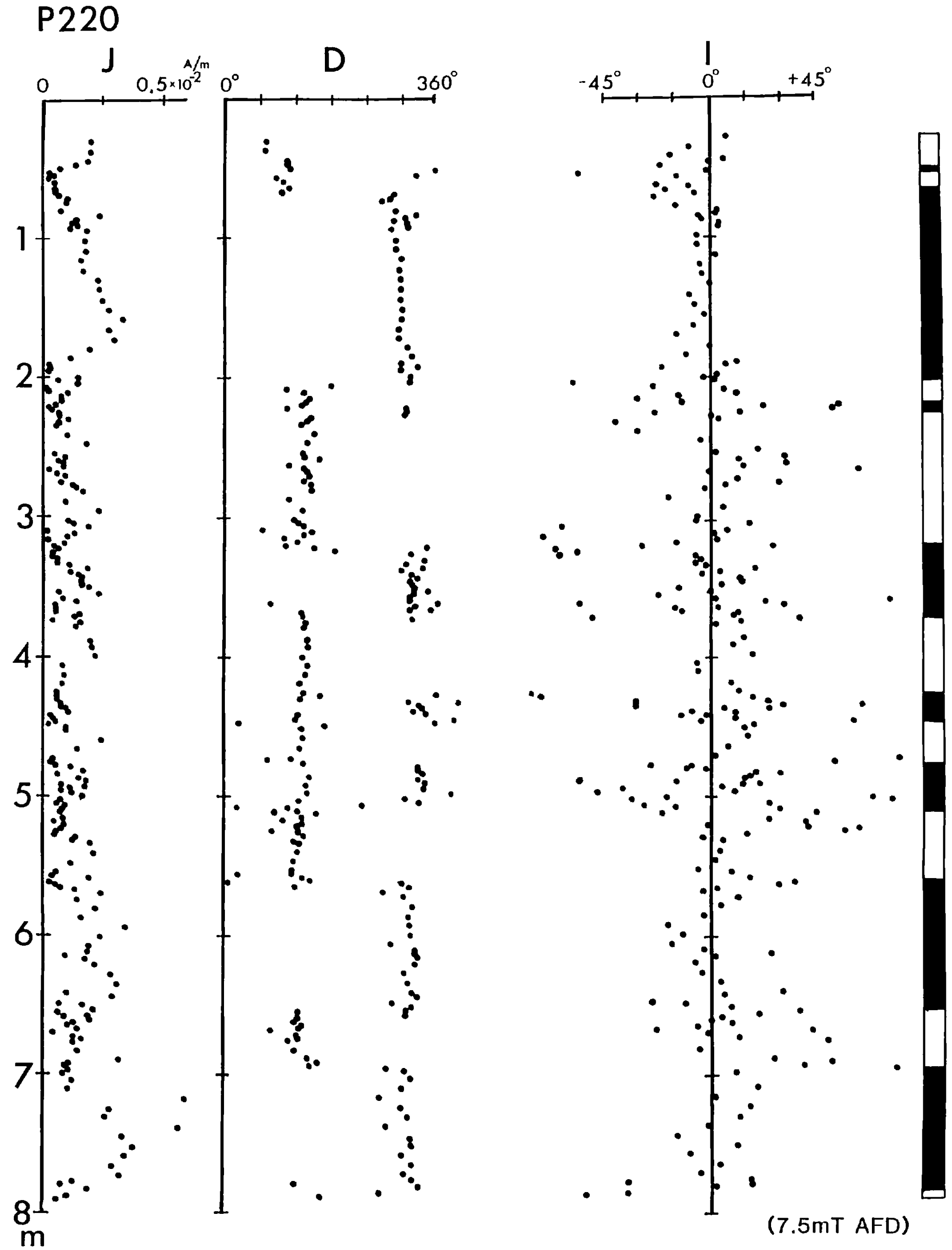

Fig. XI-2(3)

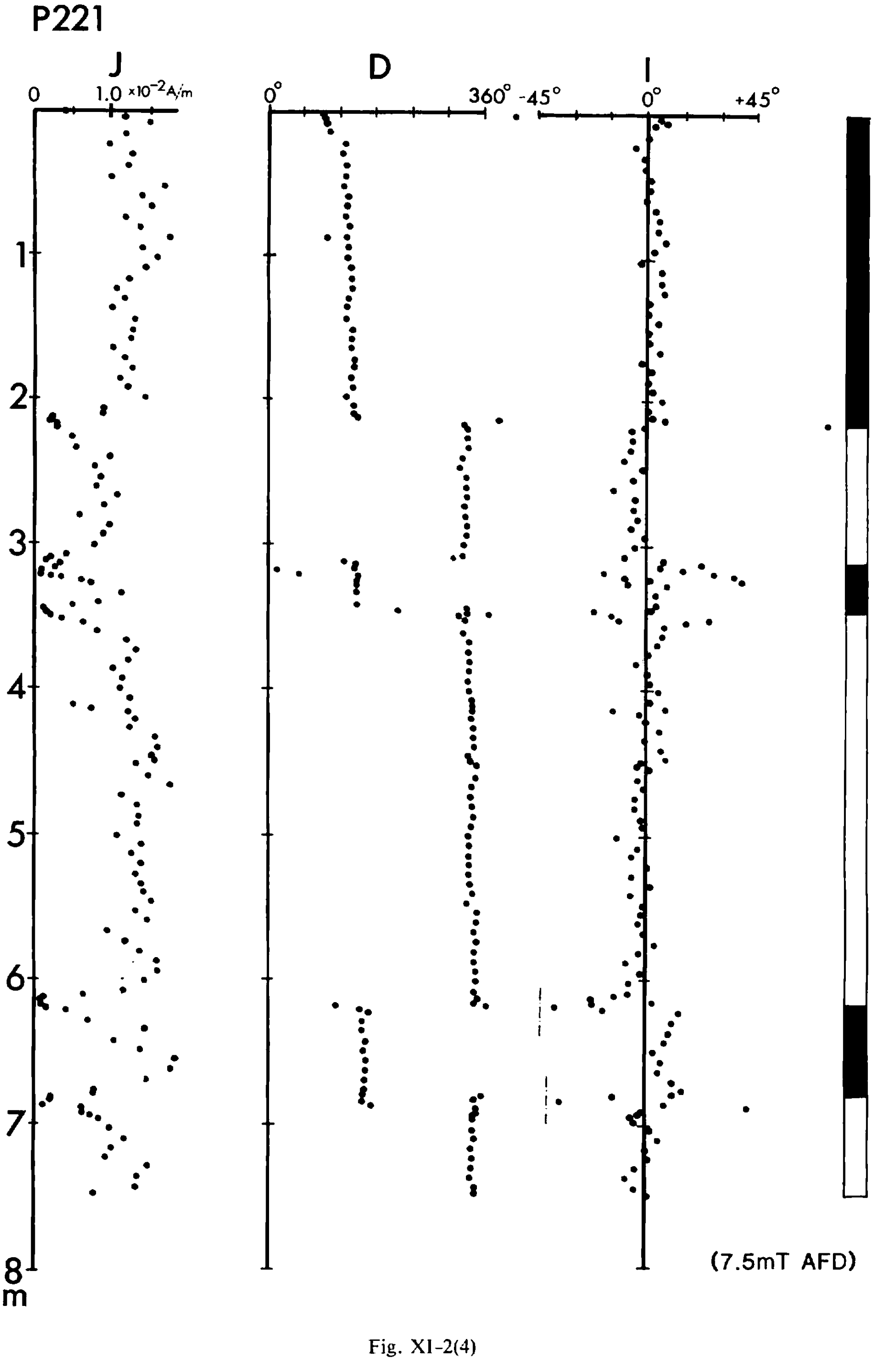

Fig. XI-2(4)

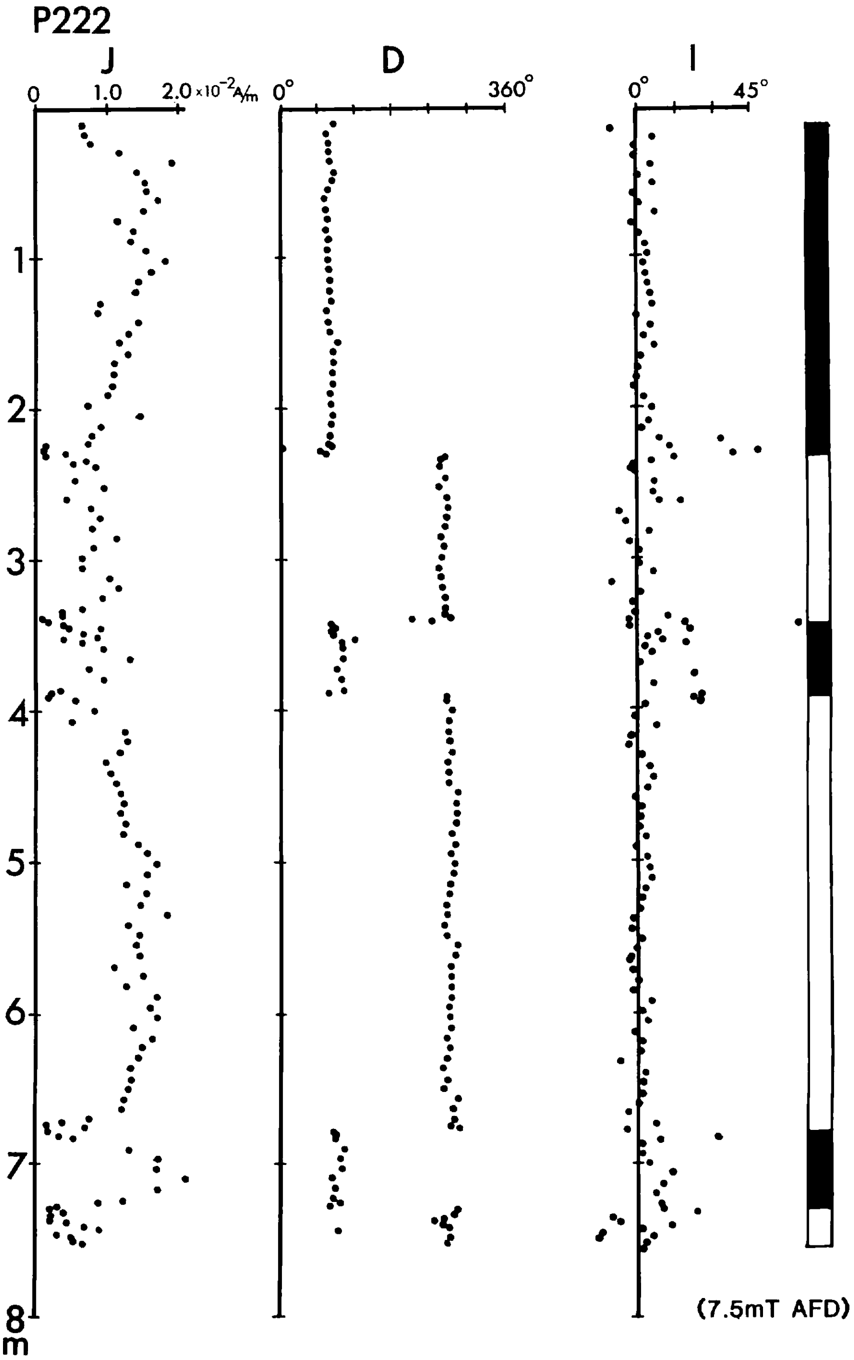

Fig. XI-2(5)

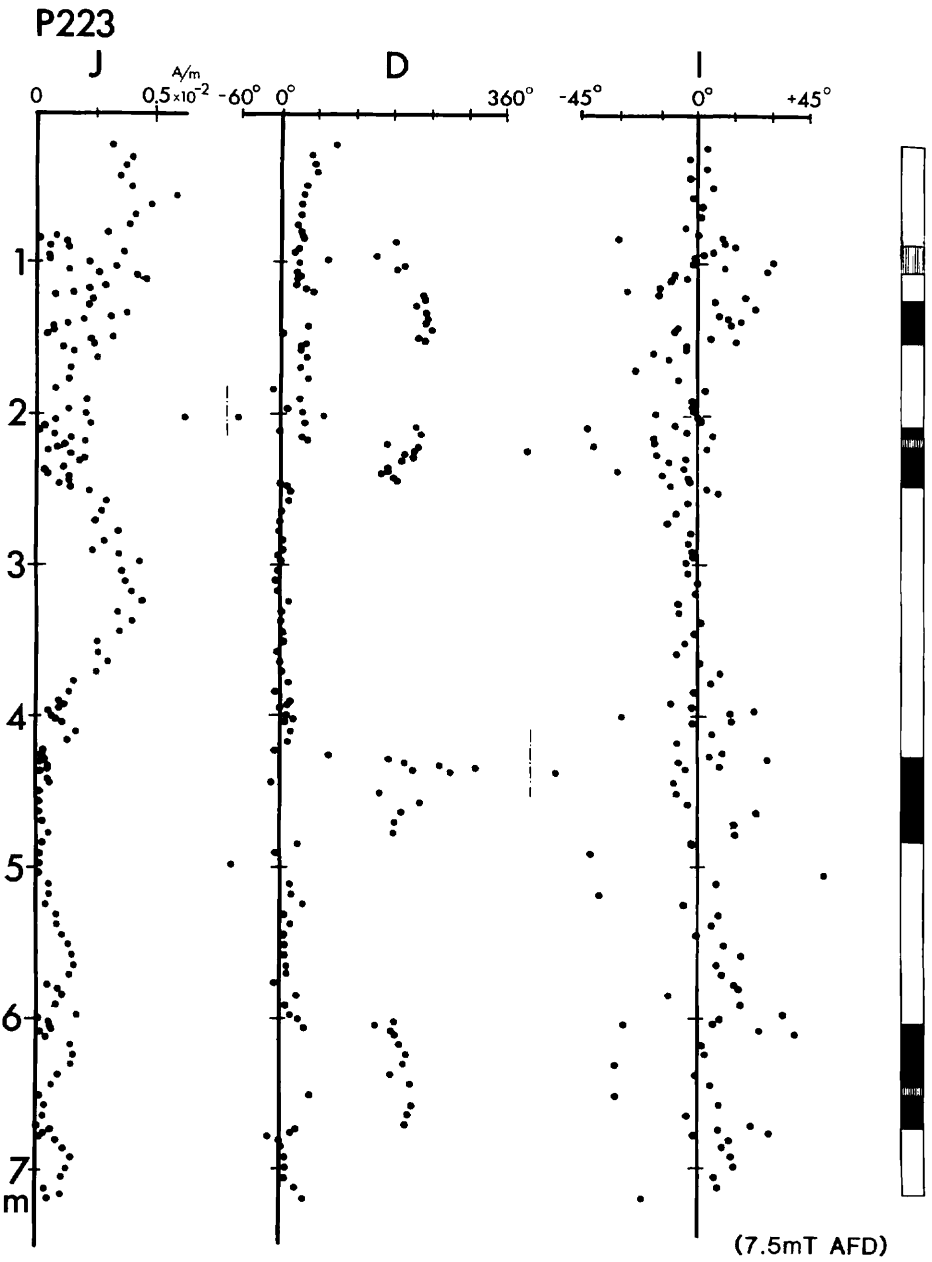

Fig. XI-2(6)

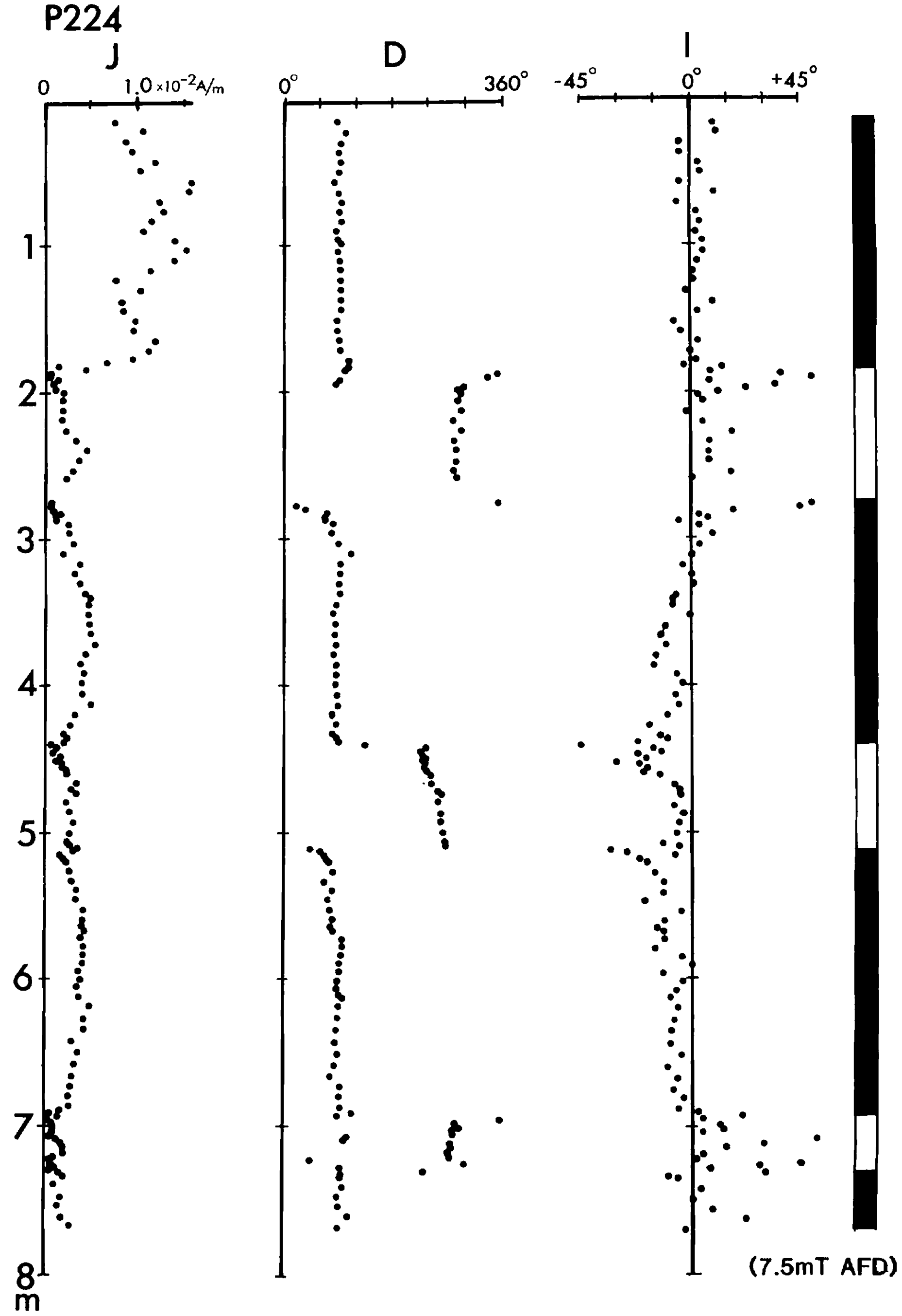

Fig. XI-2(7)

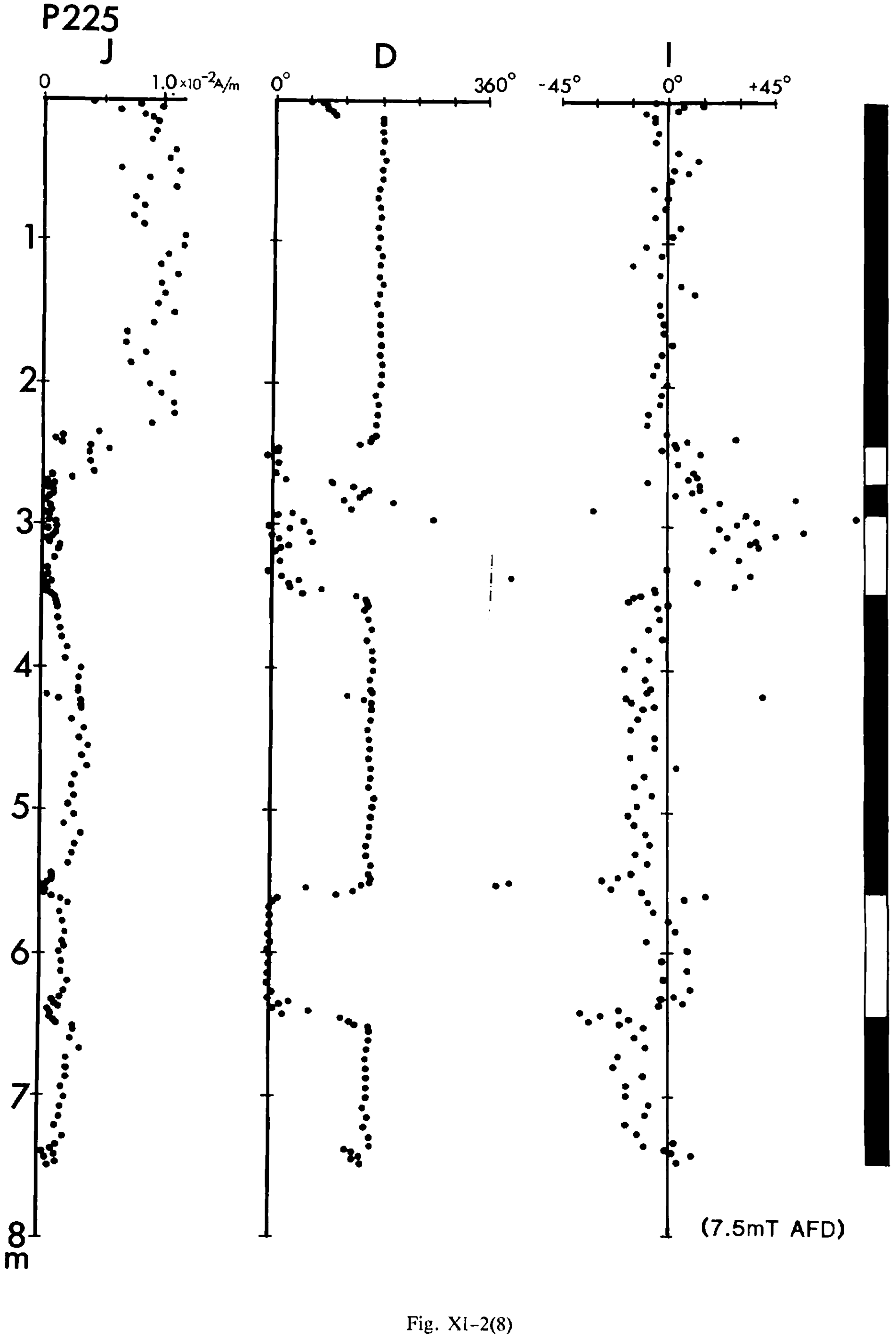

Fig. XI-2(8)

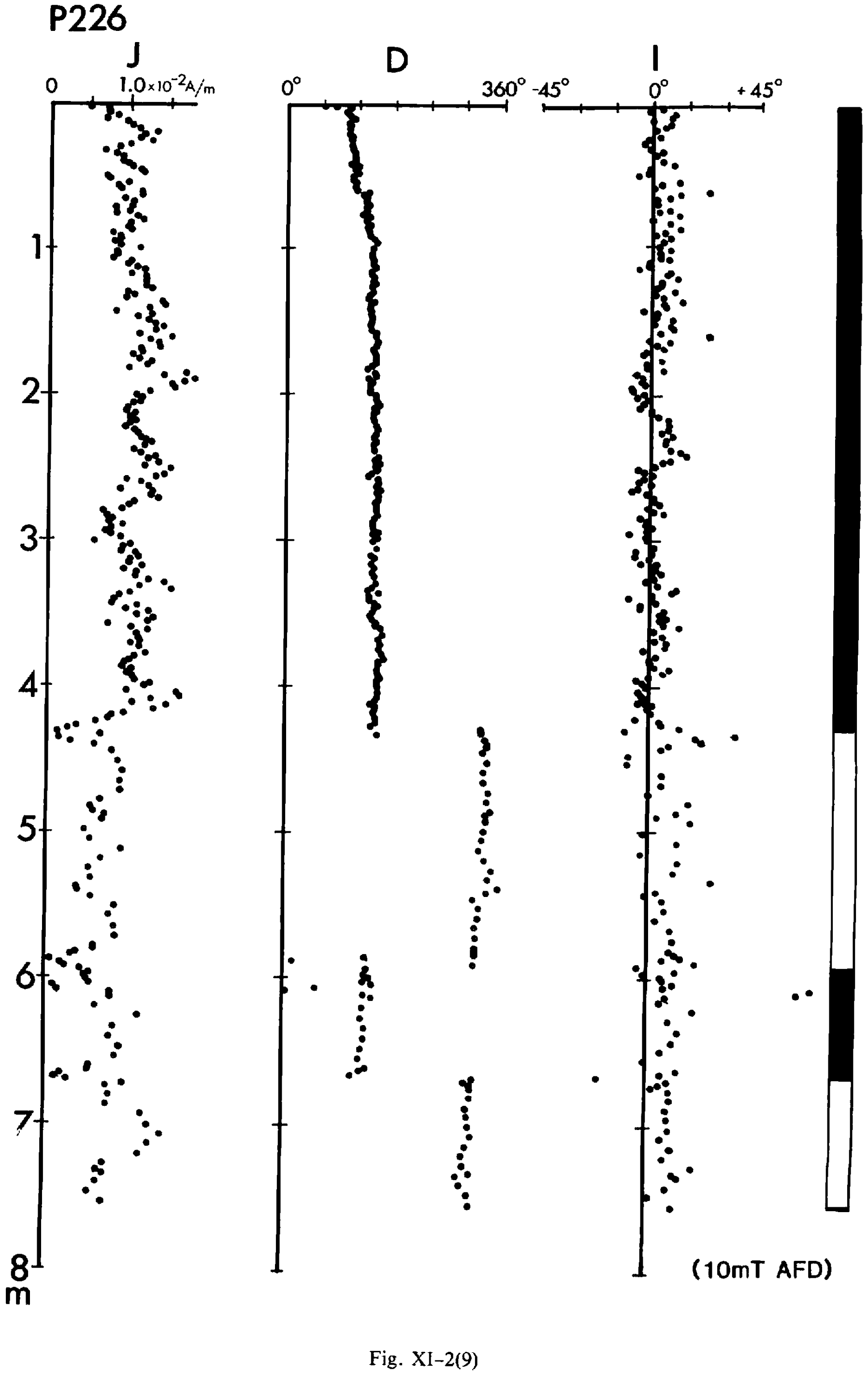

Fig. XI-2(9)

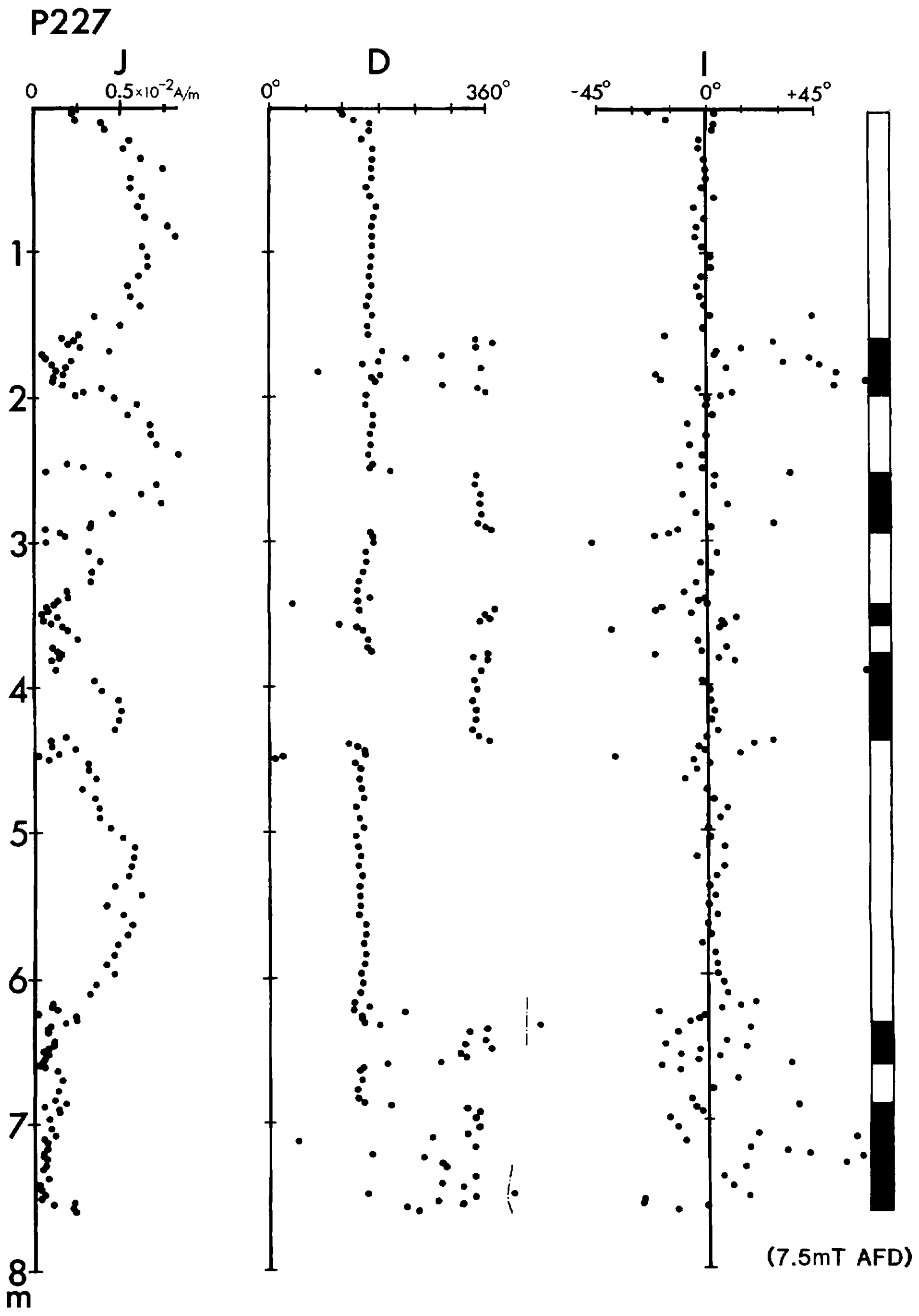

Fig. XI-2(10)

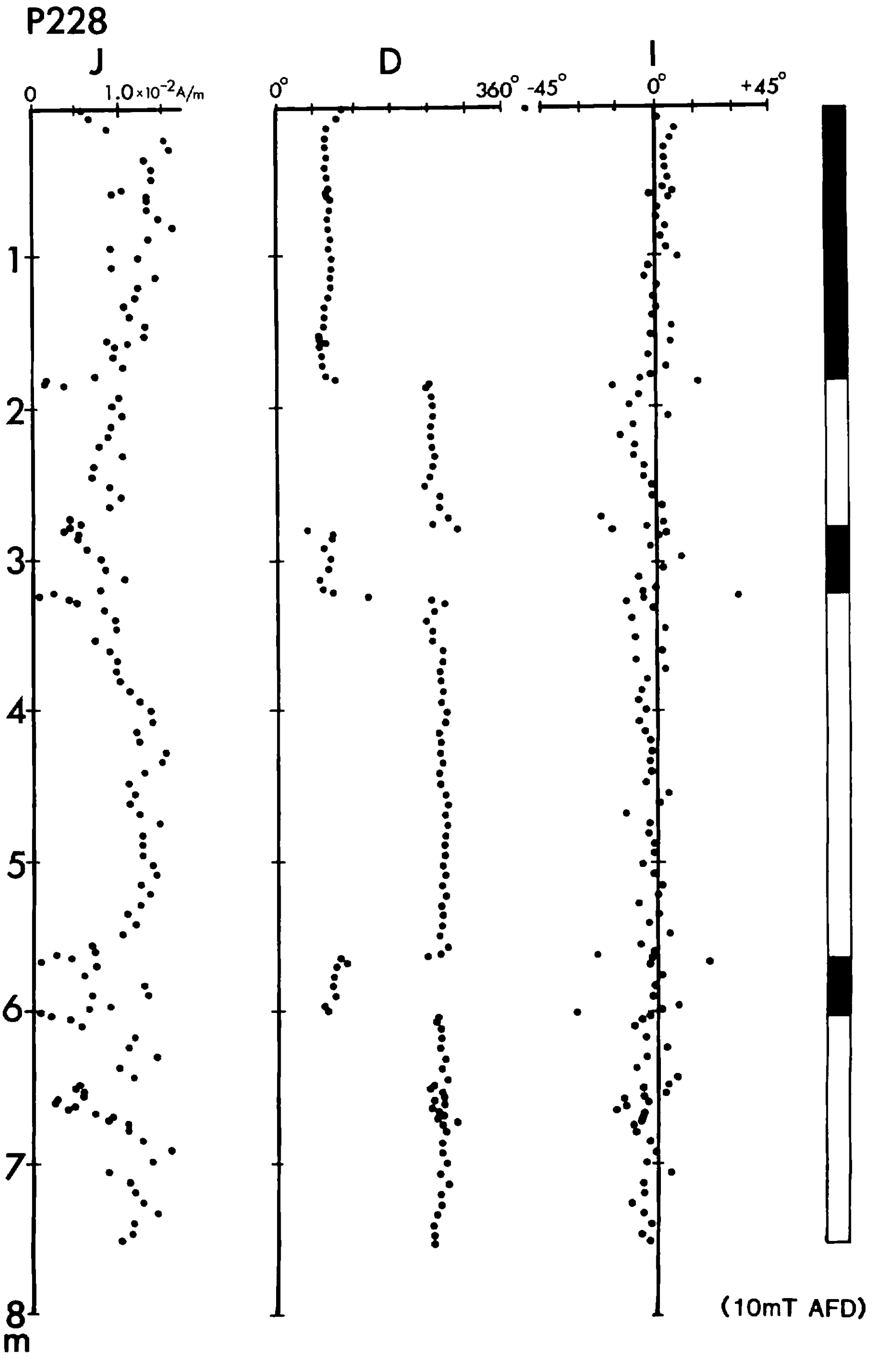

Fig. XI-2(11)

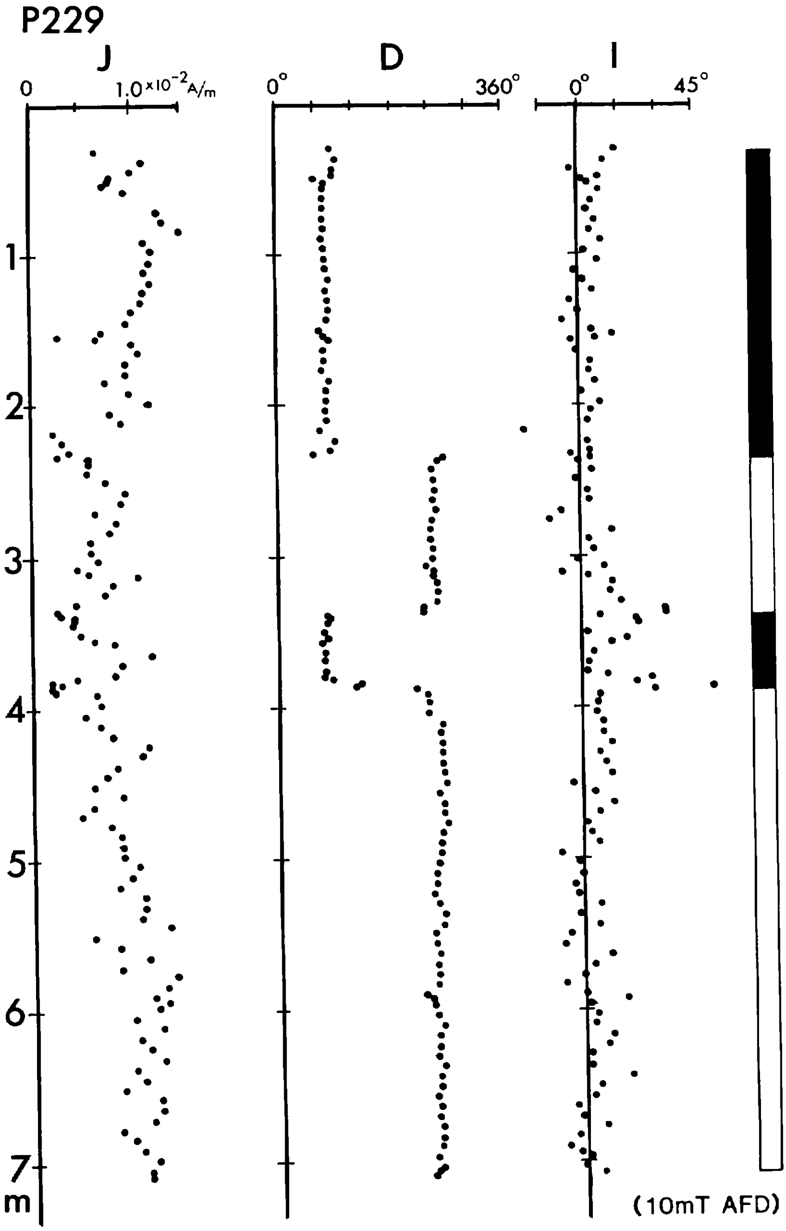

Fig. XI-2(12)

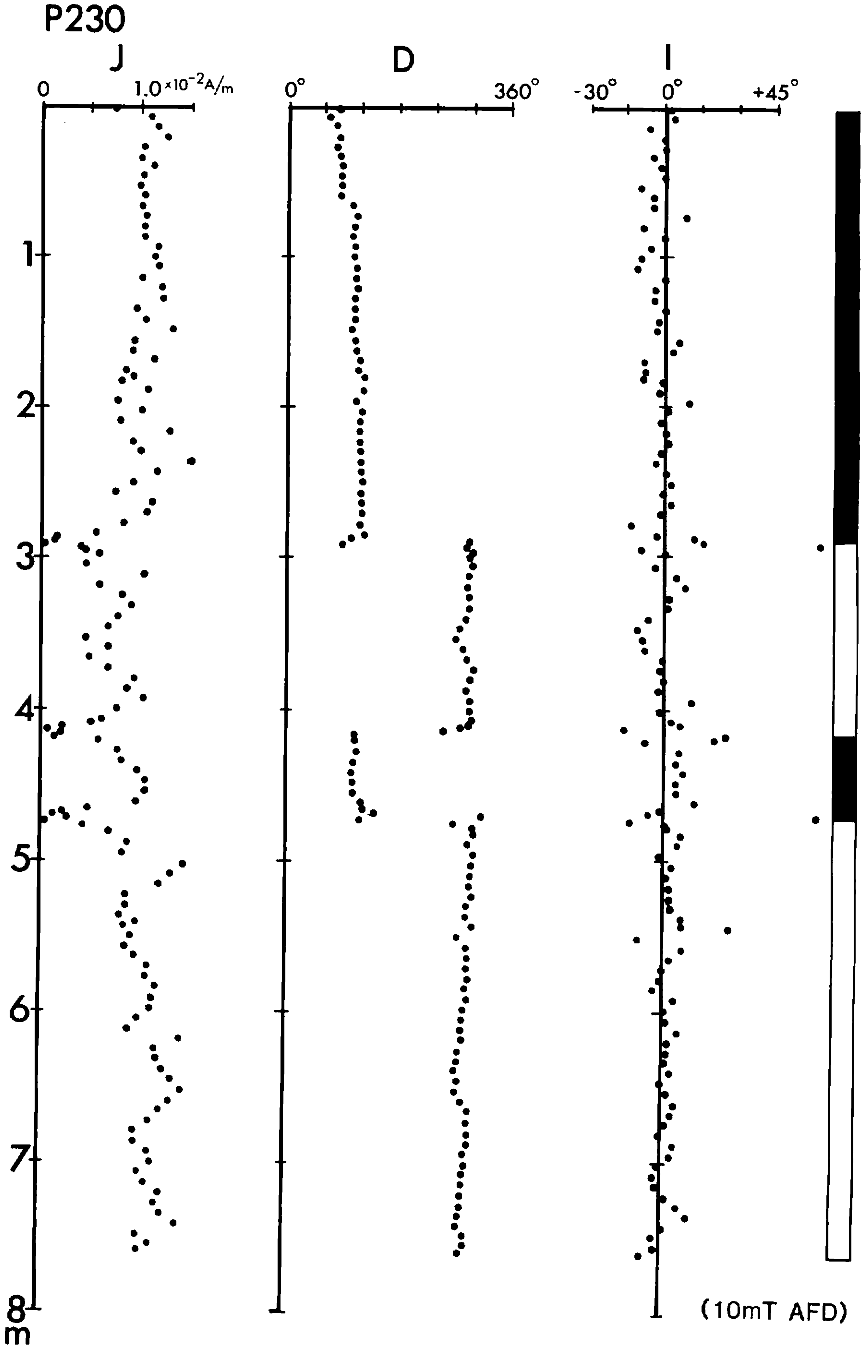

Fig. XI-2(13)

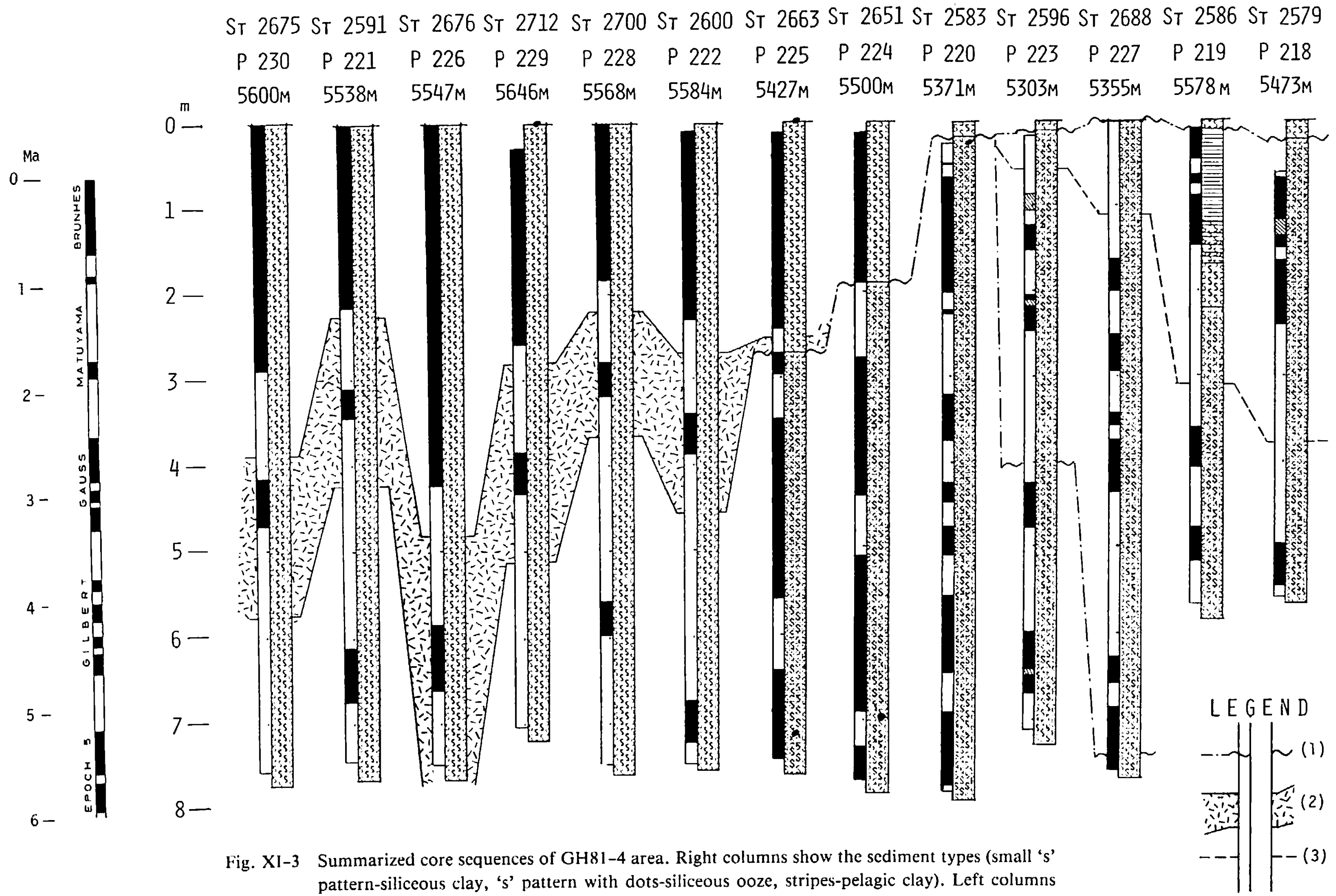

Fig. XI-3 Summarized core sequences of GH81-4 area. Right columns show the sediment types (small 's' pattern-siliceous clay, 's' pattern with dots-siliceous ooze, stripes-pelagic clay). Left columns show the magnetic polarity of sediment cores. (1) hiatus, (2) *Mesocena quandrangula* Zone (0.79–1.3 Ma), (3) top horizon of *Spongaster pentus* Riedel and Sanfilippo (ca. 3.4 Ma).

Epoch. It is, therefore, inferred that these cores have had continuous sedimentation. The second normally magnetized part from the top, which is included in the *Mesocena quandrangula* Zone (ca. 1.3 to 0.79 Ma, BERGGREN *et al.*, 1980), can be certainly correlated to the Jaramillo Event (0.91 to 0.98 Ma). A sharp break of the intensity of the remanence around 6.60 m of Core P228 (Fig. XI-2(11)) where no lithologic change is observed may indicate the short normal event which is known as the Reunion Event (2.01 to 2.04 Ma, HARLAND *et al.*, 1982). Such a short event as this is not easily detected from a core consisting of the pelagic sediments which have very low sedimentation rate because it would be recorded only as a short drop of the intensity of remanence (NIITSUMA, 1977; HYODO, 1984).

The cores from the deep-sea hills, on the other hand, have hiatuses of various durarions.

Cores P218, P219, P220, P223 and P227 have no, or very thin if any, Quaternary sediments. A hiatus since the Pliocene or the late Miocene can be recognized around the top of these cores. Except for Core P220 the top horizon of the *Spongaster pentas* (latest Gilbert Epoch, THEYER *et al.*, 1978) exists in these cores. This horizon gave a good control point to identify the Gauss and/or the Gilbert Epoch.

Cores P218 and P219 indicate the late Gilbert Epoch (4.0 Ma and 4.3 Ma respectively) at their bottoms, and about the boundary between the Gauss Epoch and the Matuyama Epoch (about 2.4 Ma and 2.7 Ma respectively) at their tops. For Core P227 existence of a hiatus between 7.30 m and 7.66 m is estimated from radiolarian biostratigraphy. Above the hiatus its reversal sequence corresponds well to the standard from 5.8 Ma to 3.5 Ma, while below it the correspondence to the standard is unclear.

The age of Core P220 will range from 14.6 Ma to 8.7 Ma inferred from an estimated radiolarian age (10.5 to 11.2 Ma at 2.98 m and 11.1 to 15.5 Ma at 7.66 m) and the resemblance of its magnetic reversal pattern to the standard. At the depth of about 3.5 m presence of an insignificant hiatus is supposed from that the fitness to the standard polarity time scale is not good there (Fig. XI-4(b)).

For Core P223 the correspondence of its polarity sequence to the standard is quite vague. A hiatus is estimated at 4.2 m (polarity boundary) from radiolarian ages and a drop in the intensity of the remanence. The reversal pattern above the hiatus would be that of the Gilbert Epoch. Below it the standard polarity sequence from 10 to 12 Ma may be fitted, which is inferred from the same radiolarian age (10.5 to 11.2 Ma, from 4.40 m to 7.25 m) as that of Core P220.

Cores P224 and P225 have the Quaternary sediments of a few meters thick which are underlain by the early Miocene sediments. From radiolarians, the uppermost normally magnetized part can be identified to the Brunhes Epoch, and the ages of the bottom of the cores, 7.49 m (P224) and 7.20 m (P225), are estimated to be the early Miocene (20.7 and 23.2 Ma). Existence of a hiatus is expected at 1.85 m (P224) and 2.70 m (P225) from a visually remarkable change in lithology and a drop (about an order of magnitude) of the intensity of the remanence (Fig. XI-2(7) and (8)) at these horizons. The polarity sequence below the hiatus may indicate the age from 18 Ma (P224) or 19 Ma (P225) to 21 Ma, but other possibilities (from 21 Ma to 22 Ma, for example) can not be excluded.

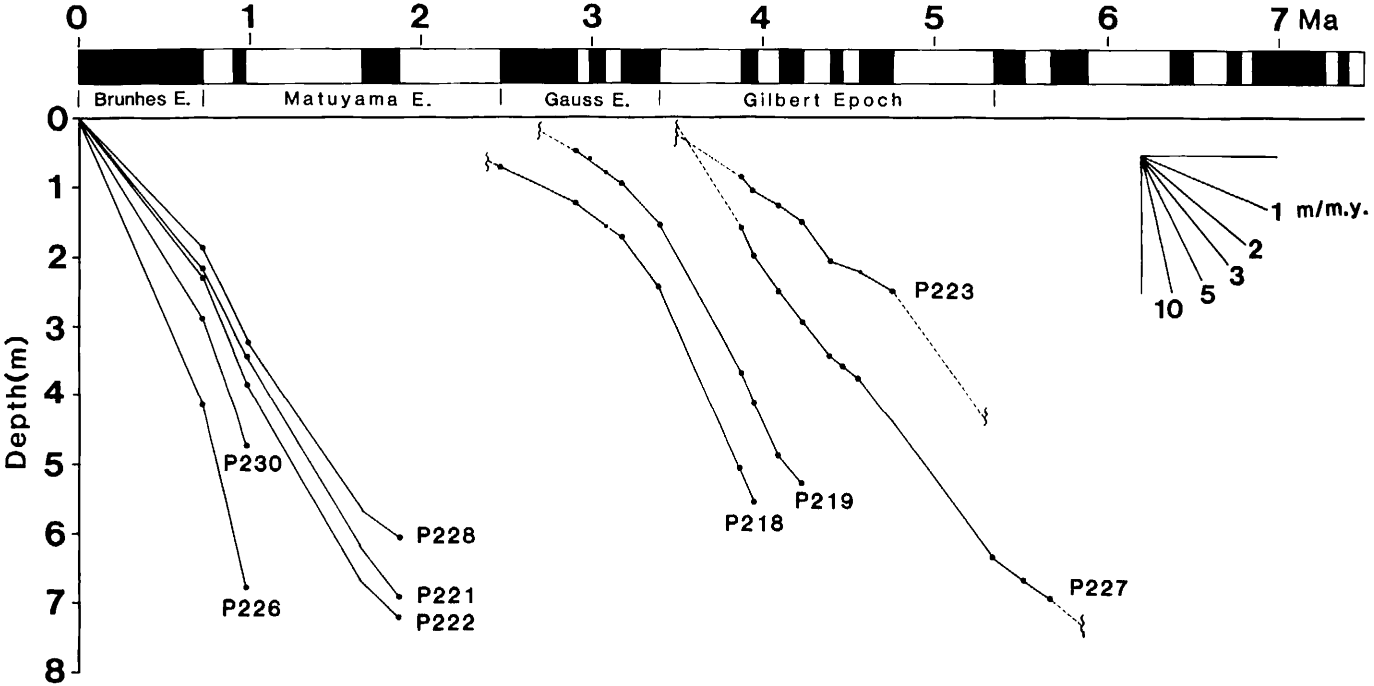

Fig. XI-4(a)

Fig. XI-4(a)-(c) Plots of the time versus depth for thirteen cores. The time scale of BERGGREN *et al.* (1985) is adopted.

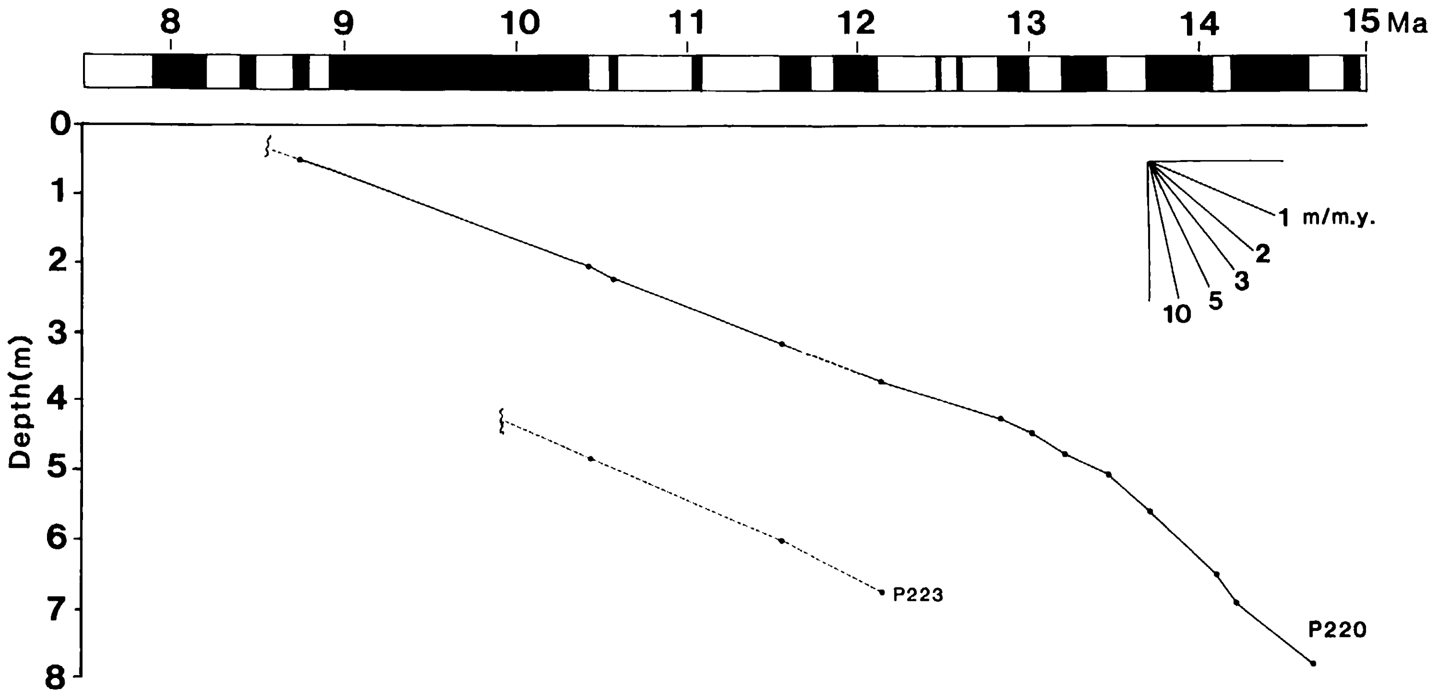

Fig. XI-4(b)

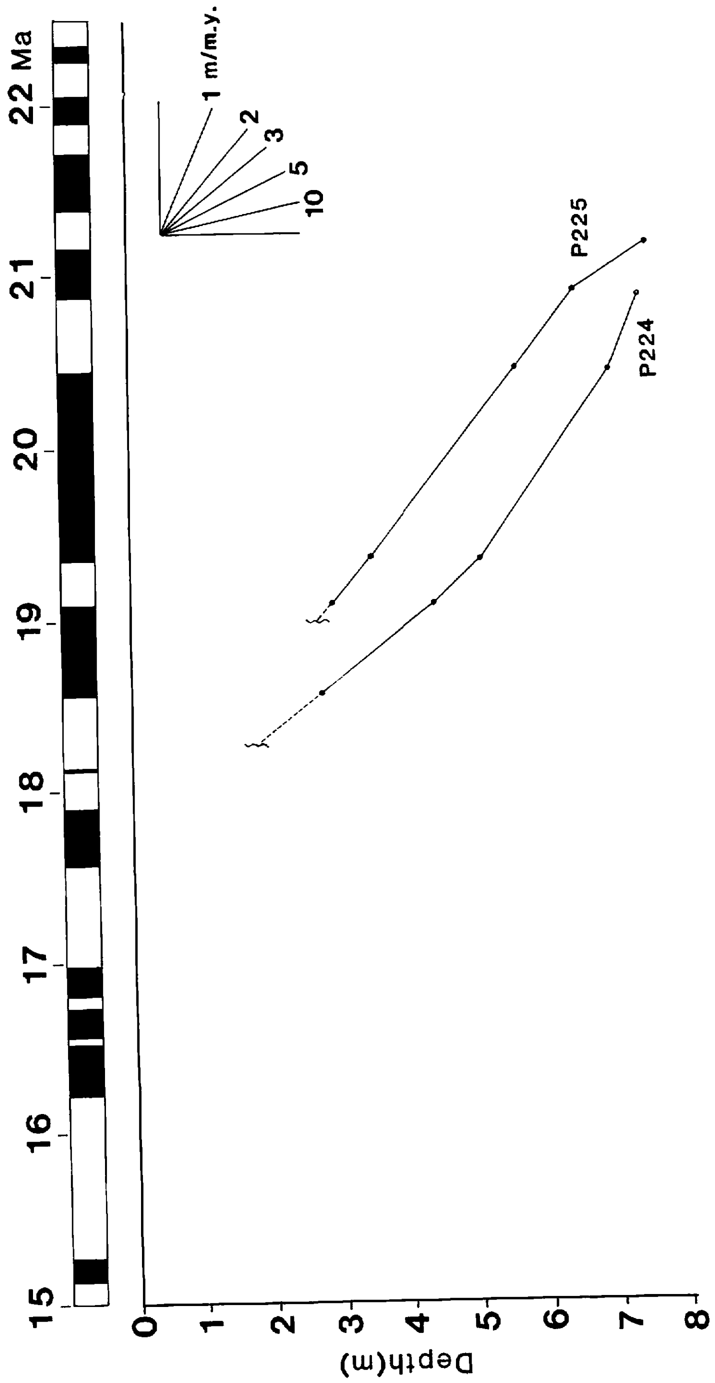
15
16
17
18
19
20
21
22 Ma
0
1
2
3
4
5
6
7
8
Depth(m)
1 m/m.y.
2
3
5
10
P225
P224

Fig. XI-4(c)

The age of the youngest sediments below hiatuses (considering all hiatuses but the older ones in P223 and P227) is about 2.5 Ma (P218), and that of the oldest sediments above them is about 0.8 Ma (P225). It can be estimated, therefore, that the formation of a hiatus was intensified in the period from the latest Pliocene to the early Pleistocene. Presence of the hiatus at this period has been reported for some other cores from the Central Equatorial Pacific (KOBAYASHI *et al.*, 1971; OPDYKE *et al.*, 1974; THEYER and HAMMOND, 1974; JOSHIMA, 1982). The intensified currents of the AABW (Antarctic Bottom Water) is thought to be most responsible for the formation of the hiatus (VAN ANDEL *et al.*, 1975).

Sedimentation rates

Figure XI-4 shows the time versus depth for the thirteen cores. Variation of the sedimentation rate from the early Miocene to the Quaternary can be read from the figure.

The sedimentation rate in the Quaternary was 3 to 6 m/m.y. (the avarage of each core). The rate is relatively high for pelagic sediments below the CCD because the sampling sites have been beneath the zone of high productivity near the equator. Around the Jaramillo Event the sedimentation rate was at the peak, 5 to 10 m/m.y.. Subsequently the rate somewhat reduced. There is, however, a possibility that the sedimentation rates in the Brunhes Epoch is underestimated because the very surface sediments were sometimes missed during the sampling. But the thickness of the missed surface sediments would not exceed several tens of centimeters as usual, so it can be safely said that in the Brunhes Epoch the sedimentation slowed down.

The early Miocene and the early Pliocene are marked by relatively high sedimentation rate, 3 m/m.y. or more. The middle to late Miocene and the late Pliocene are, on the other hand, the periods of low rate (less than 2 m/m.y.). The paleolatitude of the study area at 20 Ma deduced from the absolute motion models of the Pacific Plate (e.g. VAN ANDEL *et al.*, 1975) was about 3° S. The area, therefore, has been in the biologically productive equatorial belt since the early Miocene. The variation of the sedimentation rate would reflect both the rise and fall of the intensity of the bottom current (AABW) and the change of the biological productivity with time.

Conclusion

Paleomagnetic study of closely spaced thirteen cores from the Central Equatorial Pacific revealed the sedimentation history from the early Miocene.

(1) Hiatuses are expected in the cores from the deep-sea hills. Their durations are (a) from the early Miocene (about 20 Ma) to the Pleistocene (about 0.8 Ma): P224, P225, (b) from the Pliocene or the late Miocene to almost the Recent: P218, P219 (from about 2.5 Ma); P223, P227 (3.5 Ma); P220 (8.5 Ma). The formation of a hiatus would be intensified in the period from the latest Pliocene to the early Pleistocene.

(2) The cores taken from the deep-sea basin (Cores P221, P222, P226, P228, P229 and P230) show continuous sedimentation during the Quaternary.

(3) The sedimentation rate was 3 m/m.y. or more in the early Miocene, the early Pliocene and the Quaternary. It was less than 2 m/m.y. in the middle to late Miocene and the late Pliocene.

(4) The sedimentation rate in the Quaternary maximized around the Jaramillo Event (5 to 10 m/m.y.) and decreased in the Brunhes Epoch (3 to 6 m/m.y.).

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