Geological Survey of Japan Cruise Report No. 20, p. 165–192, 1984

PART II

X. REMANENT MAGNETIZATION OF SEDIMENT CORES IN GH80-5 SURVEY AREA

Masato Joshima and Akira Nishimura

Introduction

Variable sedimentation rate and many kind of hiatus were revealed in the Central Pacific Basin in previous study on the sediment cores of the last GH80–1 cruise (JOSHIMA 1982). For example, P169 showed a hiatus between Gilbert epoch and present. P172, P173, P175 and P178 showed short normally magnetized part which is identified to be Brunhes epoch (JOSHIMA 1982). Also, Winterer (1973 showed a long hiatus using DSDP (Deep Sea Drilling Project) cores in the Central Pacific Basin, and Stackelberg (1982) reported a hiatus between early Miocene and late Pliocene in the east part of the Central Pacific Basin. In the present GH80–5 cruise 17 sediment cores have been obtained by piston corer in a small area of about 60×60 square miles, including the detailed survey area I consisting of a hill and deep basin, and the detailed survey area II consisting deep basin and a trough side wall and bottom as shown in Fig. X–1. Sedimentological and remanent magnetization study on these cores was carried out to get age data. The results show that though the pattern of sedimentation is somewhat similar in each other areas over the Central Pacific Basin, there may exist a variation of sedimentation pattern in a limited small area like in this cruise area where the sedimentation rate curves of cores are thought to be the same each other up to present.

Samples

All sediments sample cores were subsampled by small chloride-vinyl cases (2.3×2.3×2 cm in size). Total length of measured cores is about 115 m. Total number of specimens subsampled in small cases is about 5,000. Many of them are pelagic clay and about one-third of all is zeolitic clay. Siliceous ooze was taken only in lowest 1 m part of one core.

Measurement

Measurements were done one month after the cruise using cryogenic rock magnetometer, model c–113 by SCT. All samples were measured after the demagnetization in alternative magnetic field whose peak intensity is 75 Oe (7.5 mT). In order to get smooth decrease of alternative current in coil for effective demagnetization, the method which decreases the contact surface between copper wire and water by lowering water surface in vinyl tubes was used. The decreasing curve is shown in Fig. X–2, as compared with the case of hand-decreasing. The value of 75 Oe for demagnetization of soft component was chosen based on partial demagnetizing curve

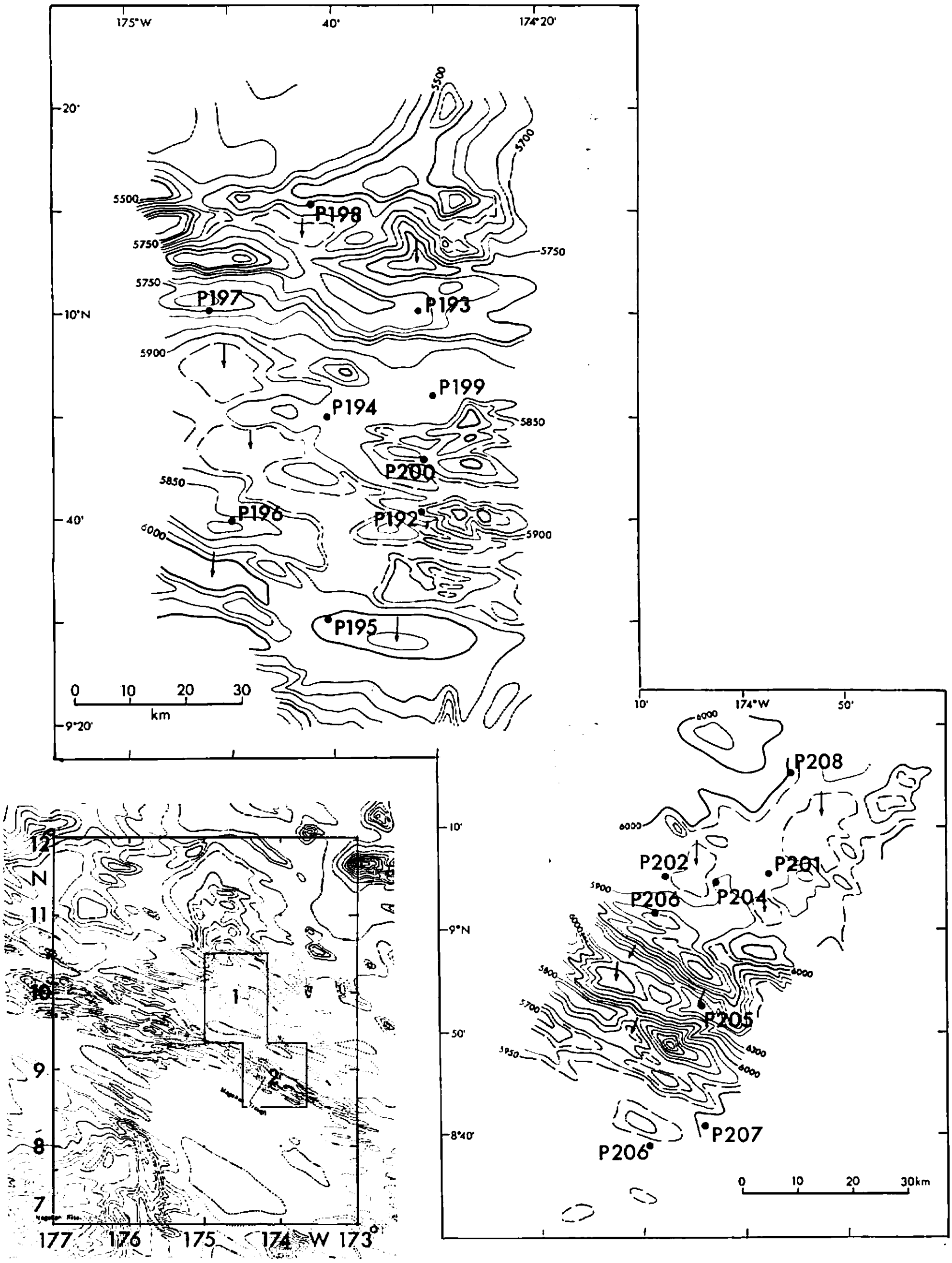


Fig. X-1 Locality map of sampling site of piston cores in the GH80-5 area.

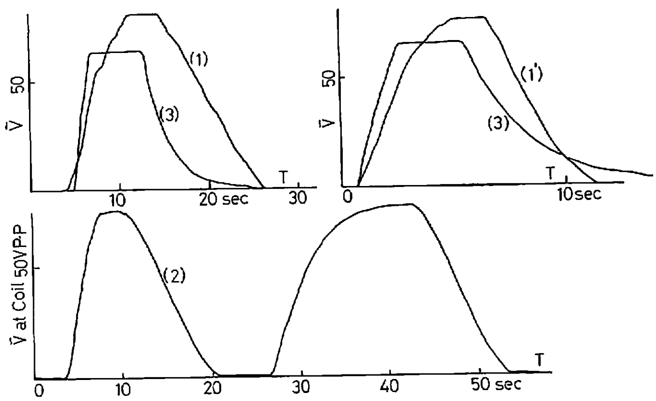


Fig. X–2 Deviced decreasing curve of alternative demagnetizing field. (1) is for man-handling of slide trance. (2) is for using water and conductive wire in long vinyl tubes. (3) is for electrical demagnetizing, now not used in this cruise report.

of some examples.

The data were taken into micro-computer, YHP model 35, using the BCD output of digital volt meter and recorded in a magnetic cassette tape. The data were compiled according to the depth of sample in a core, and plotted in a figure automatically.

Results

Table 1 shows the geomagnetic intensity and orientation calculated by IGRF (International Geomagnetic Reference Field) formula and the average inclination of top part of each core, together with the sampling location of piston cores. Many cores show stable remanent magnetization and their inclination of top parts are nearly the same value to IGRF.

Figs. X–3(1) to (17) show the data of intensity, declination and inclination, respectively for each core. Declination means relative declination because orientation of cores is unknown for us. In the right side of inclination diagram the inferred magnetized pattern was shown. Normally magnetized part is shown by solid bar and reversaly magnetized one is by open one. Figs. X–4(1) and (2) shows the summarized magnetostratigraphy and lithologic data of all cores. Generally speaking, remanent magnetization of pelagic clay is stable in many cores while that of zeolitic clay is unstable. It seems that remanent magnetization is more unstable if the sediment is more zeolitic. Remanent magnetization of siliceous clay is usually stable but that of siliceous ooze is unstable.

These characters of the remanent magnetization of core seem to have relationship to topography. P199, P200, P201, and P202 in relatively deeper areas show much zeolitic content and their remanent magnetization is unstable and almost unusable. Other cores which have small zeolitic content, such as P194 and P201 show somewhat clear patterns, but the identification of age is difficult because of their patterns that they are not connected to last normally magnetized Brunhes epoch, suggesting older age.

P192

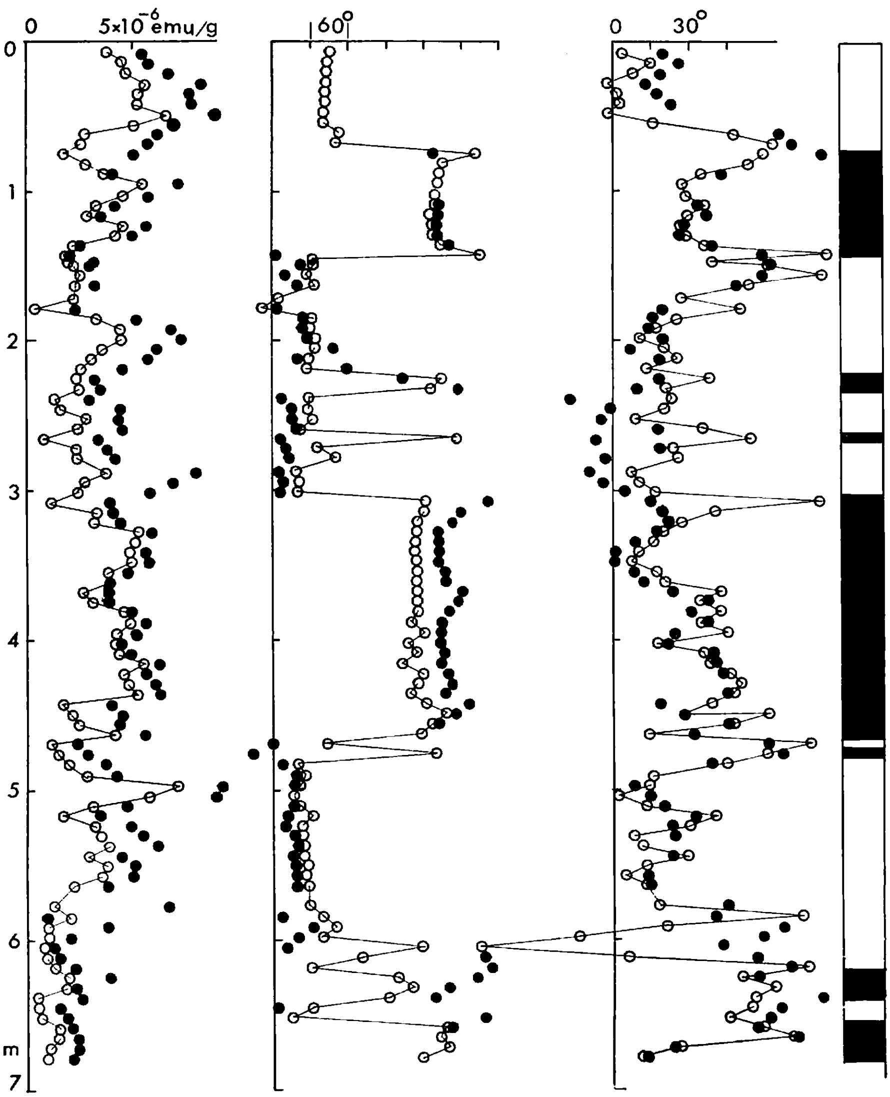


Fig. X-3 (1)

Fig. X-3(1-17) Plotted figures of magnetic properties. From left to right, intensity, relative declination, inclination and decided magnetic stratigraphy. Unit for each figure is shown in the uppermost part of figures.

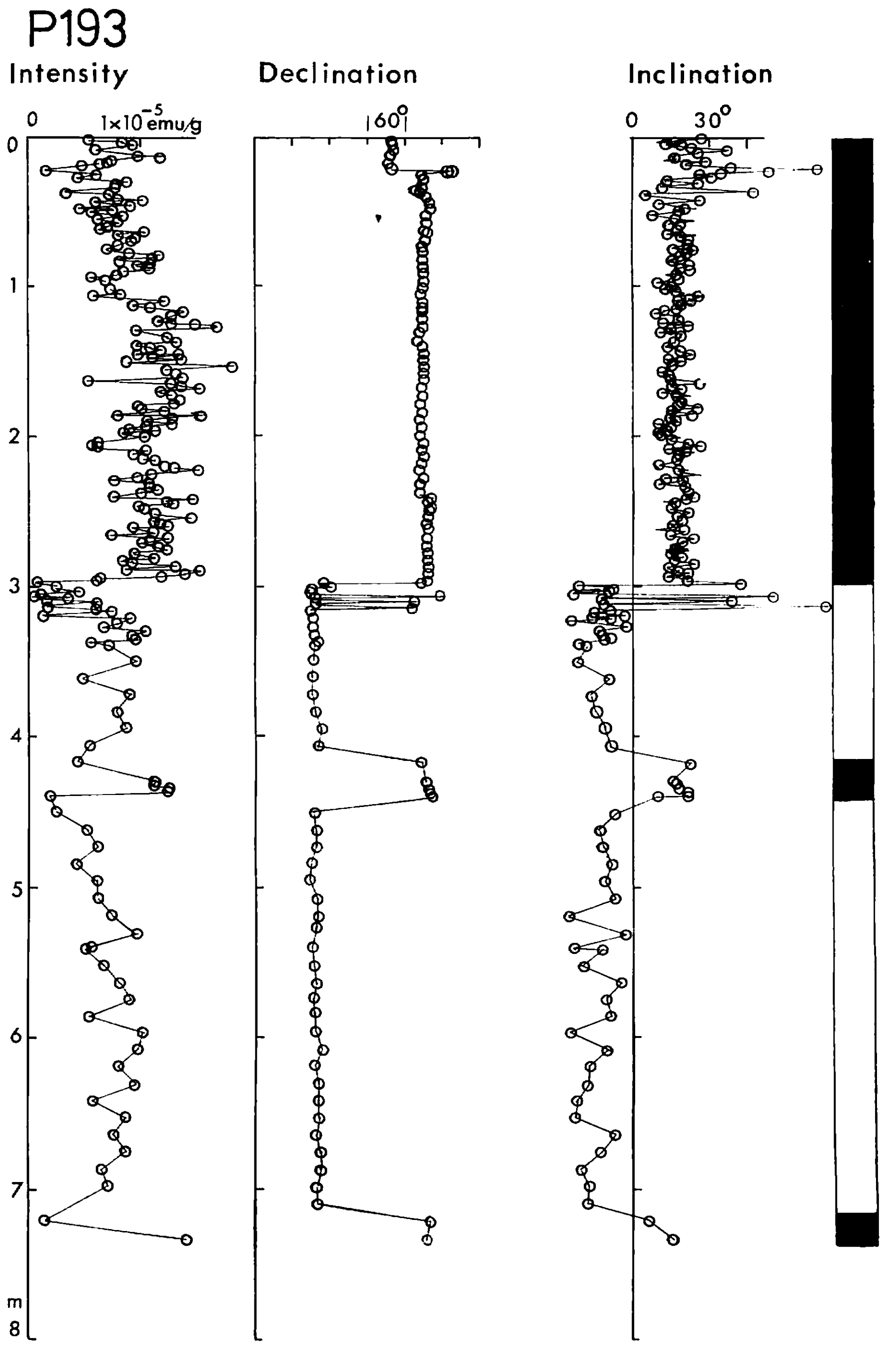

P193
Intensity
Declination
Inclination
0
1×10⁻⁵ emu/g
160°
0
30°
0
1
2
3
4
5
6
7
m
8

Fig. X-3 (2)

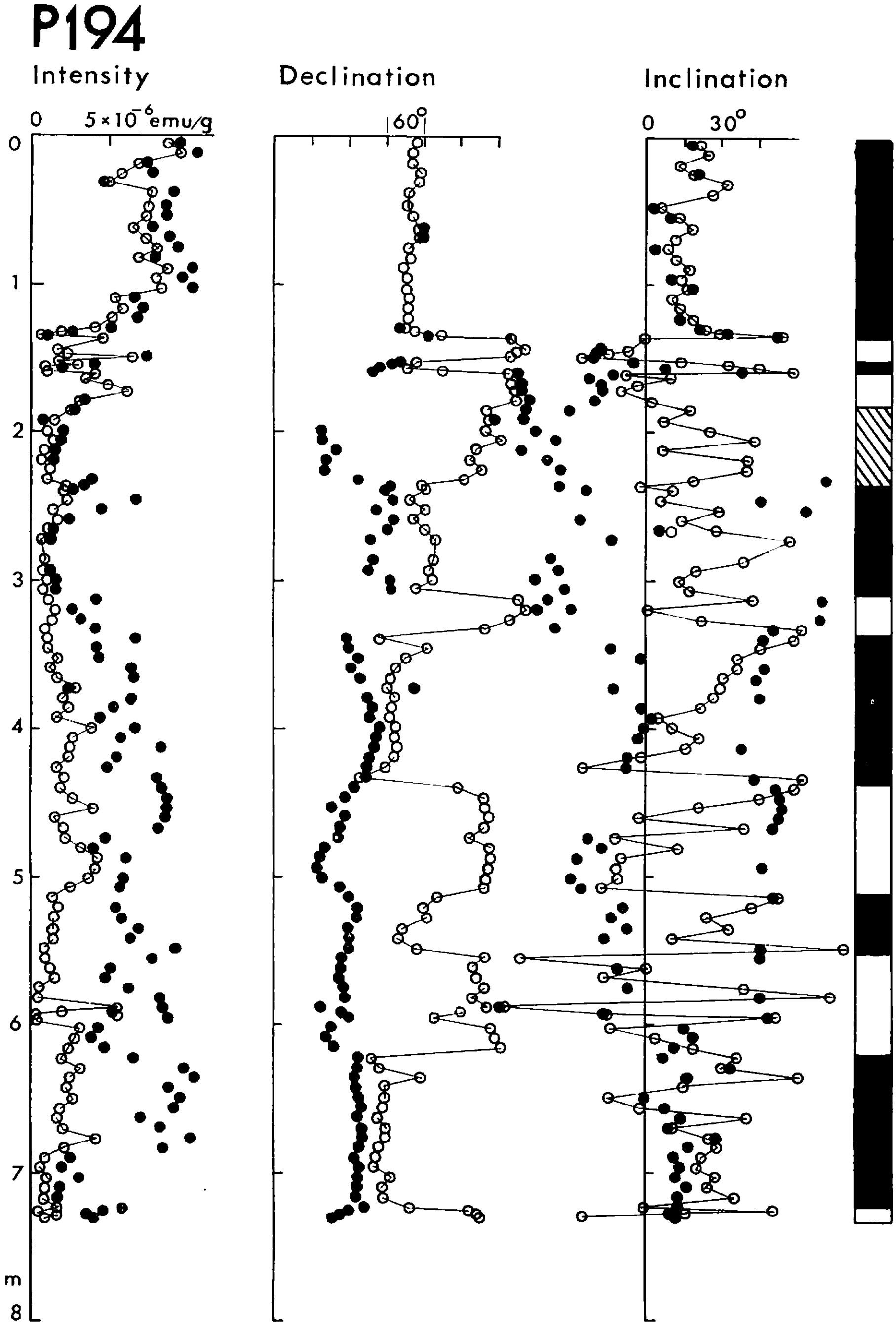

P194
Intensity
0 5×10⁻⁶emu/g
Declination
160°
Inclination
0 30°
0
1
2
3
4
5
6
7
m
8

Fig. X-3 (3)

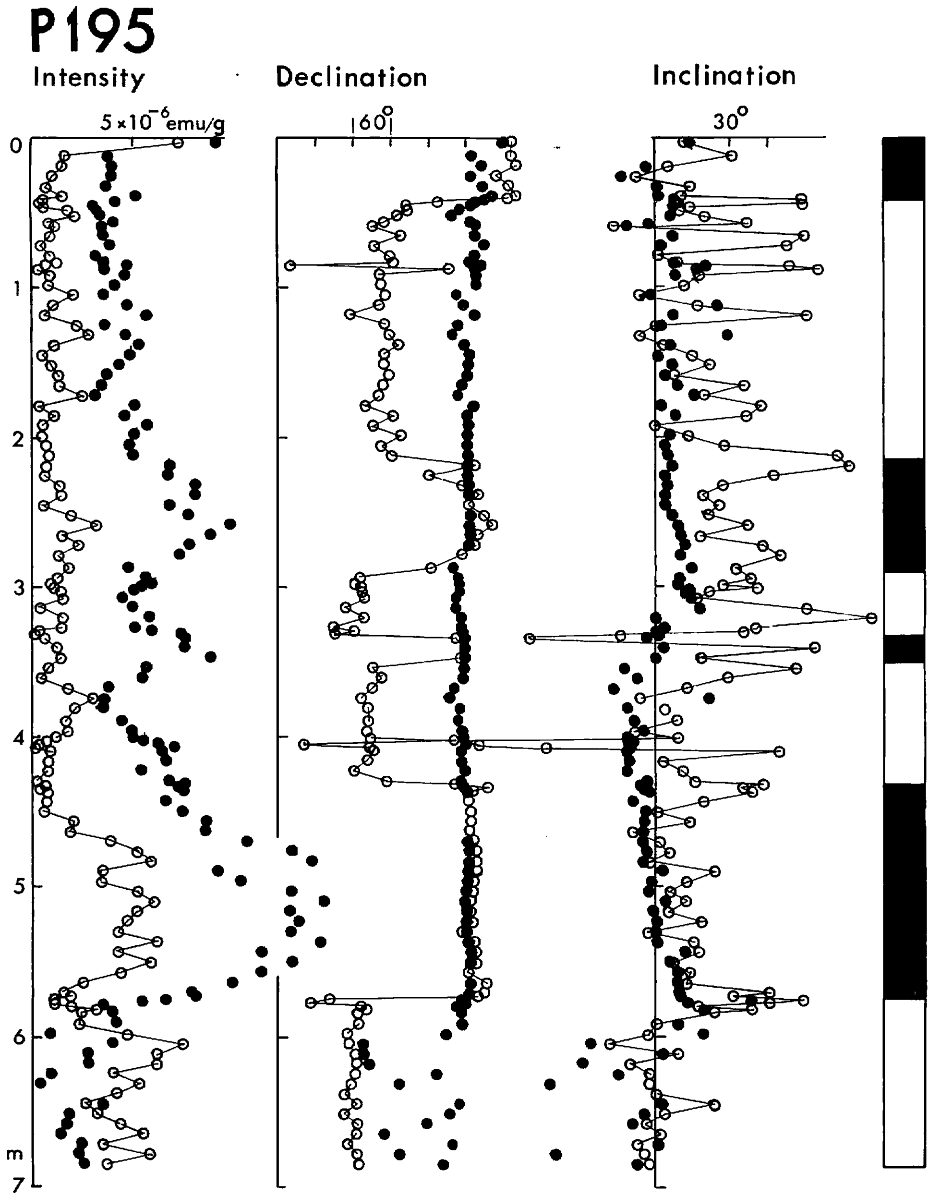
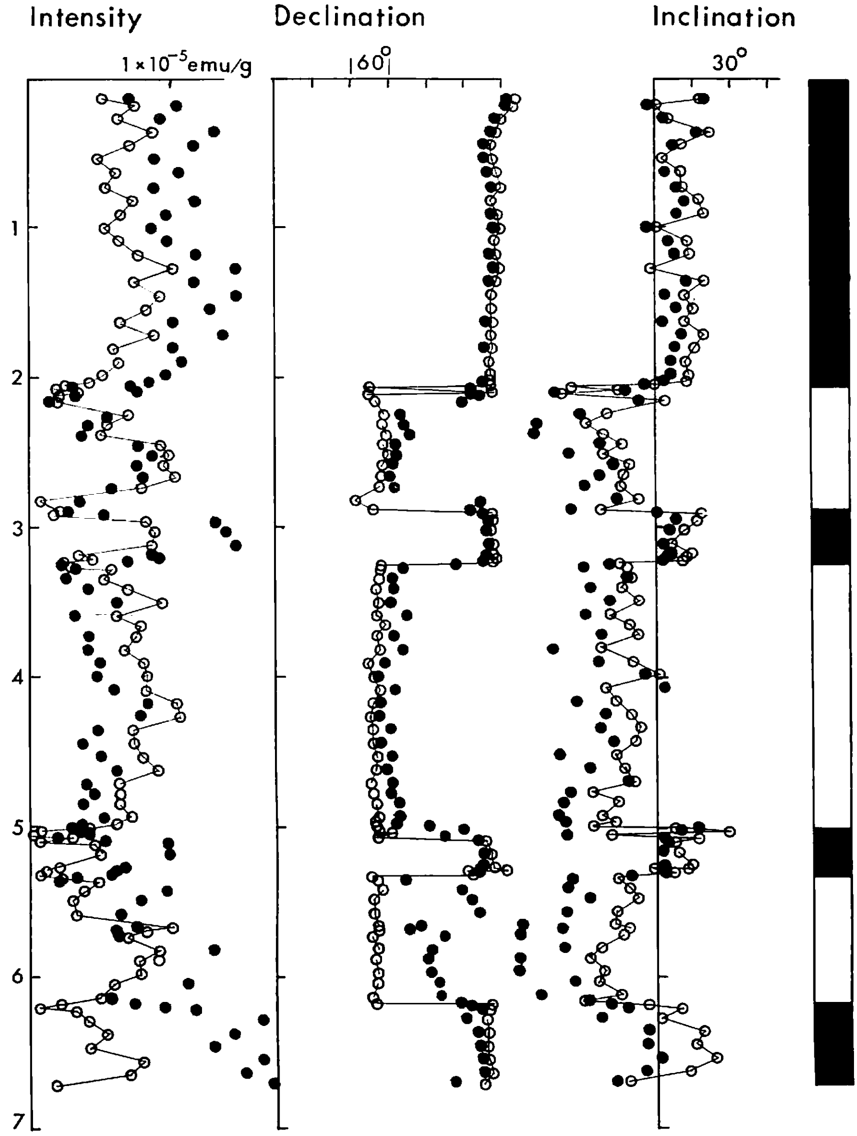

P195
Intensity
Declination
Inclination
5×10⁻⁶emu/g
160°
30°
0
1
2
3
4
5
6
m
7

Fig. X-3 (4)

P196



Intensity
Declination
Inclination
1×10⁻⁵emu/g
160°
30°
1
2
3
4
5
6
7

Fig. X-3 (5)

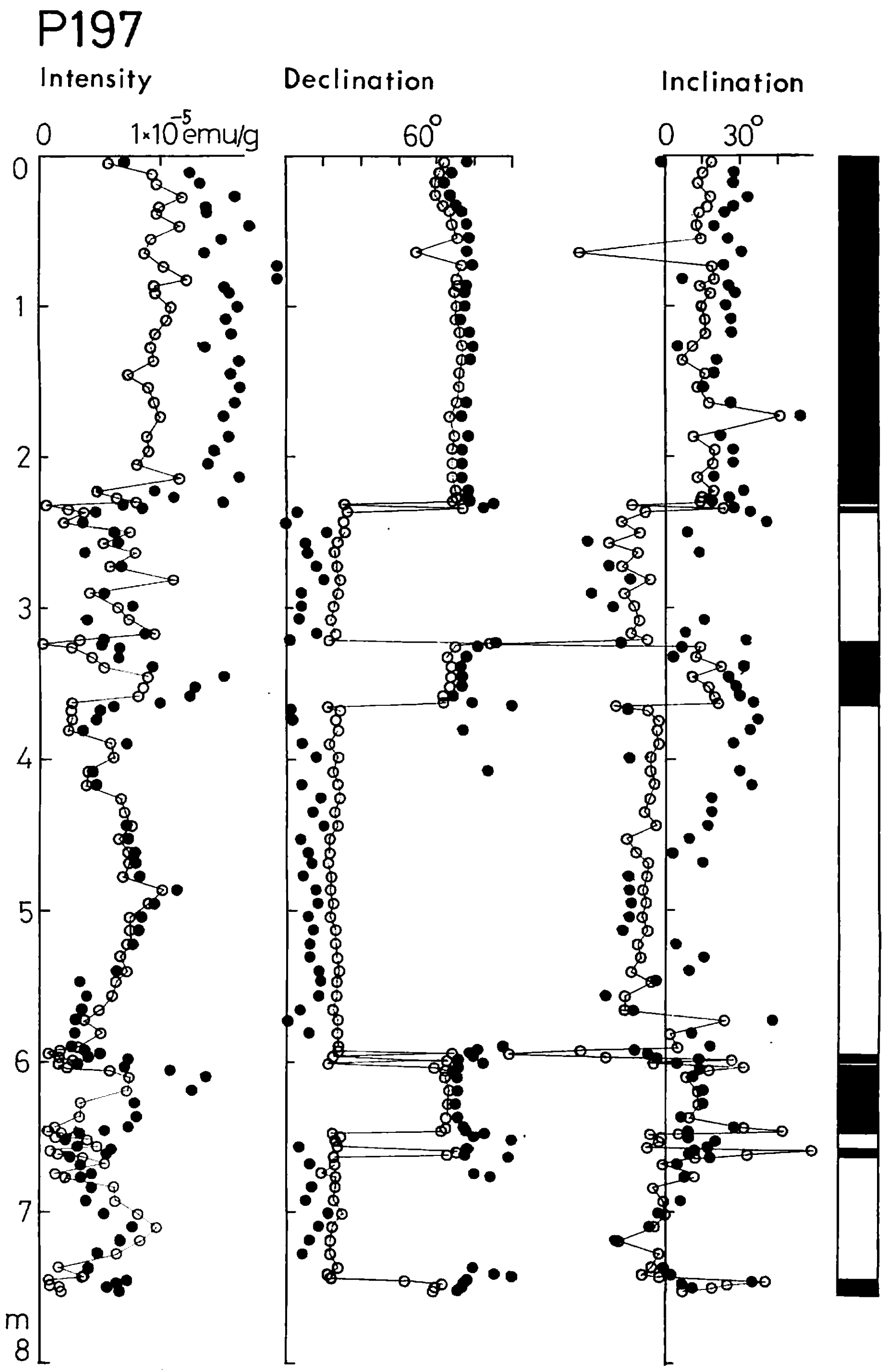

P197
Intensity
Declination
Inclination
0
1×10⁻⁵emu/g
60°
0
30°
0
1
2
3
4
5
6
7
m
8

Fig. X-3 (6)

P198

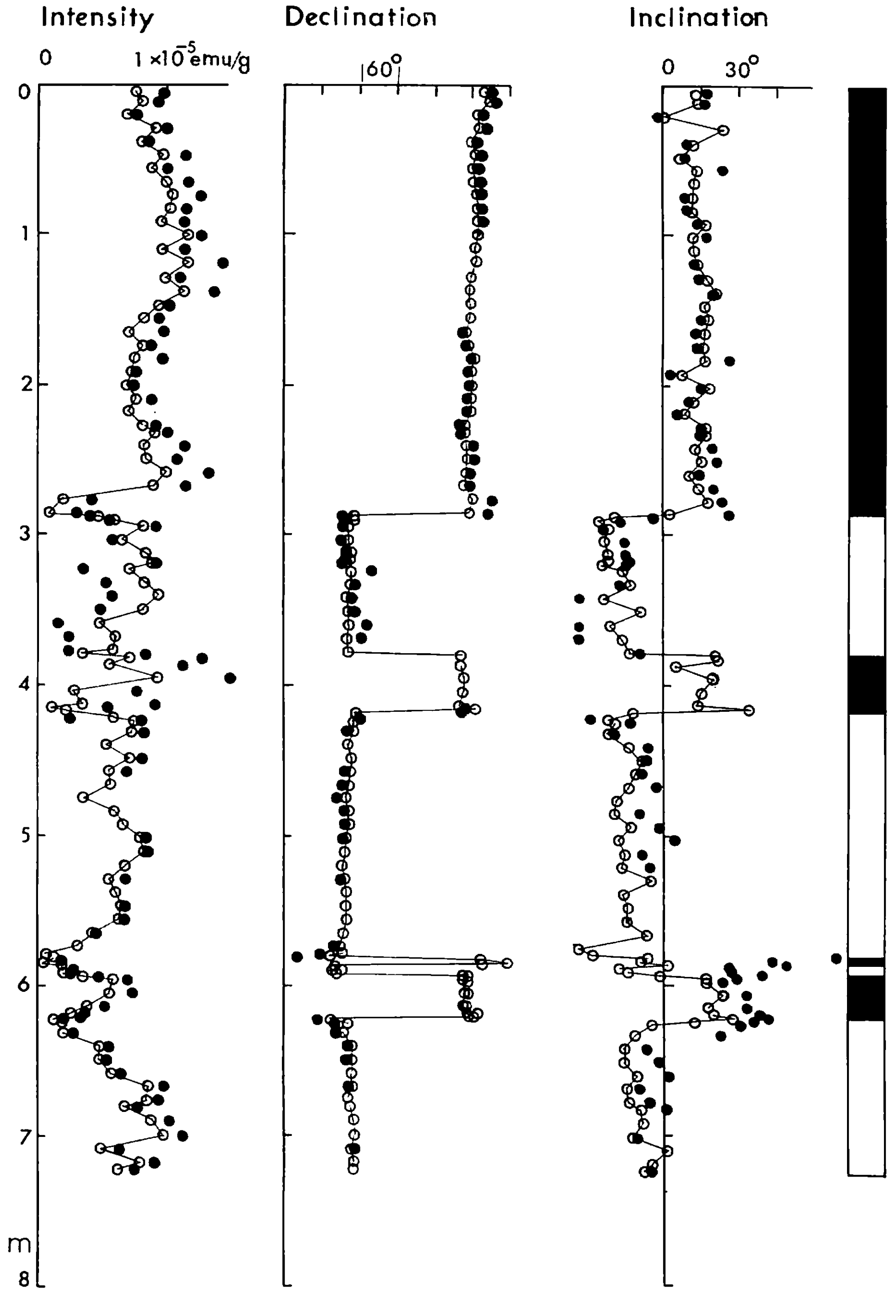

Intensity
0
1 ×10⁻⁵ emu/g
Declination
160°
Inclination
0
30°
0
1
2
3
4
5
6
7
m
8

Fig. X-3 (7)

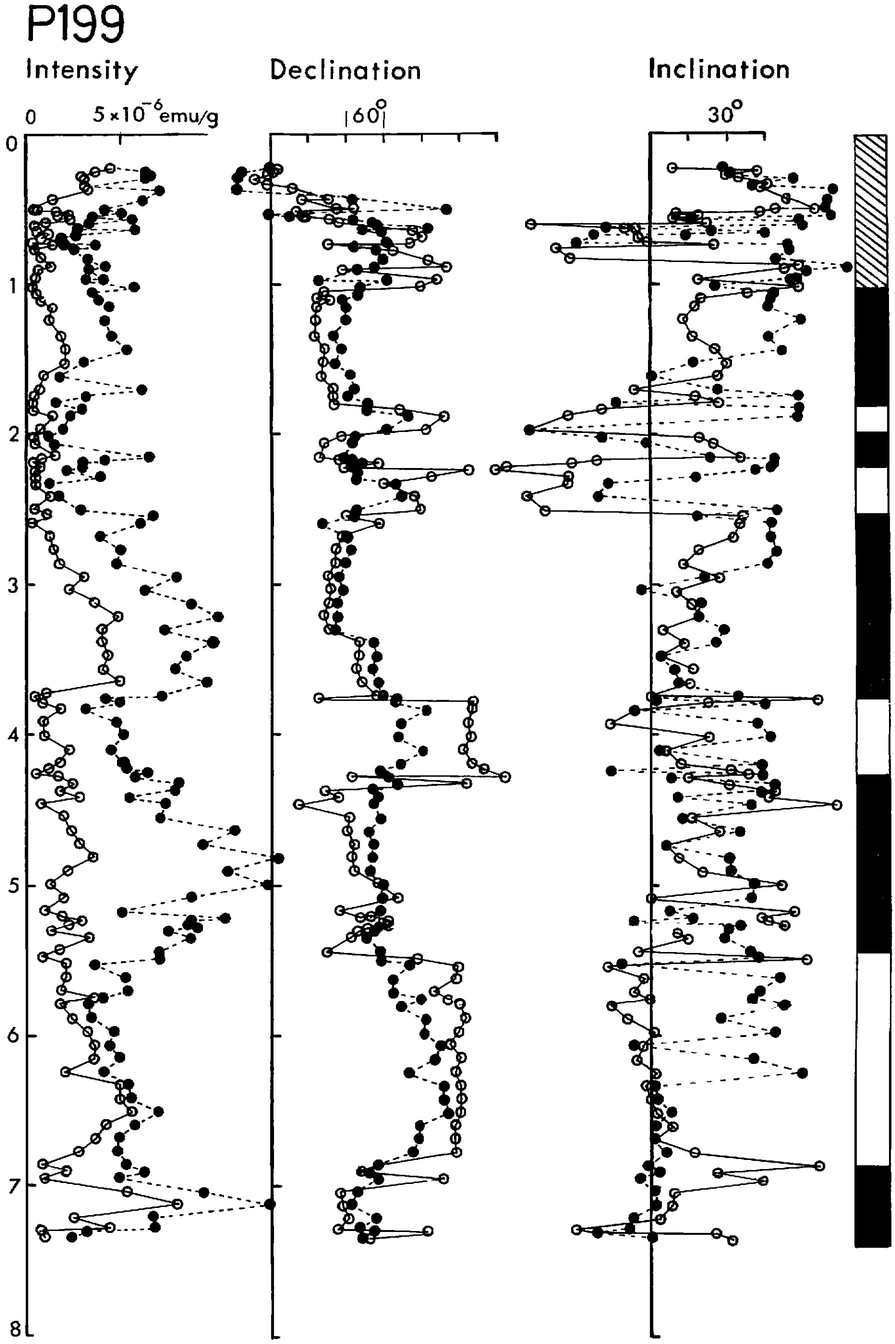

P199
Intensity
Declination
Inclination
0
5×10⁻⁶emu/g
160°
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (8)

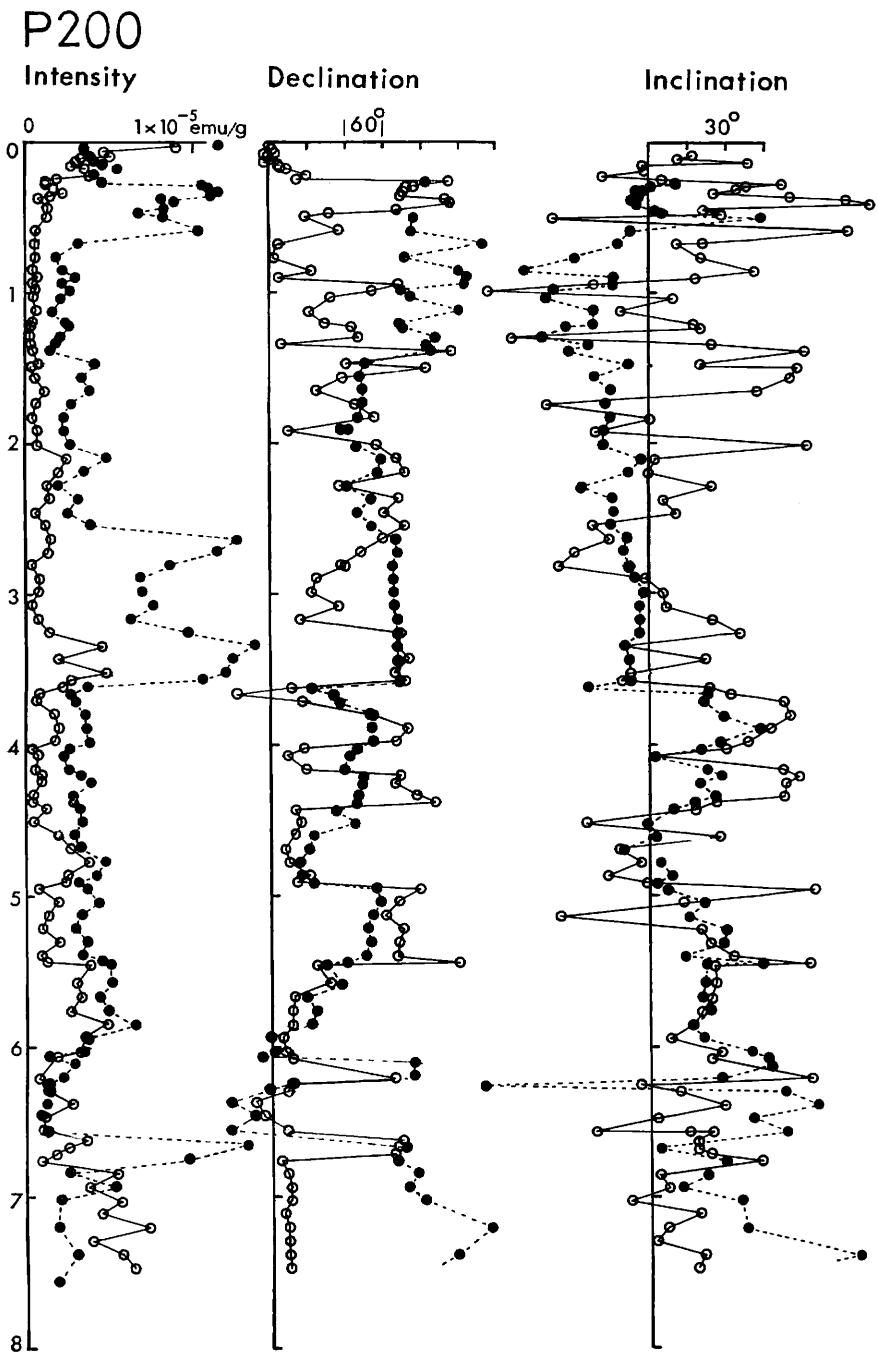

P200
Intensity
Declination
Inclination
0
1×10⁻⁵ emu/g
60°
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (9)

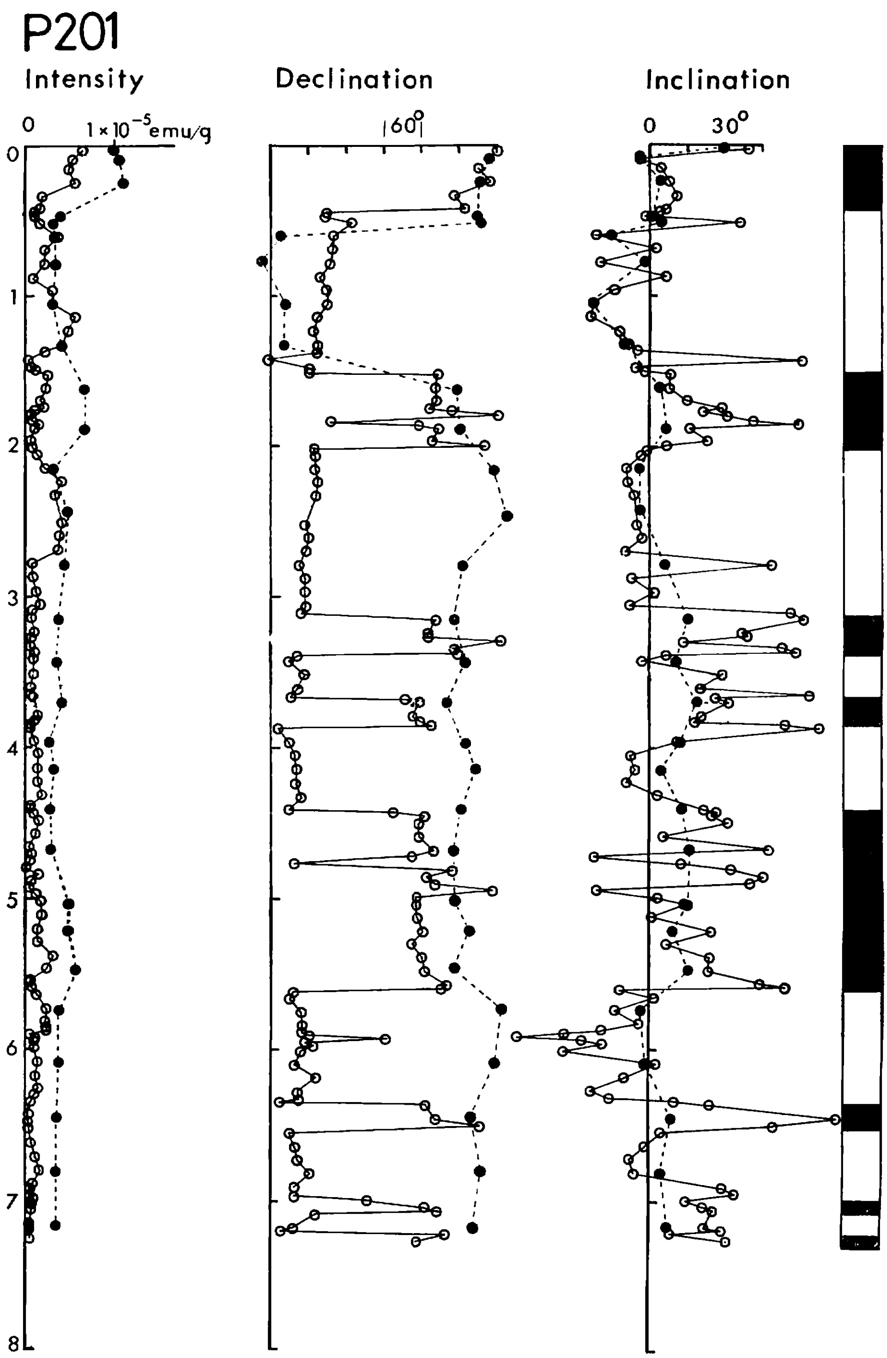
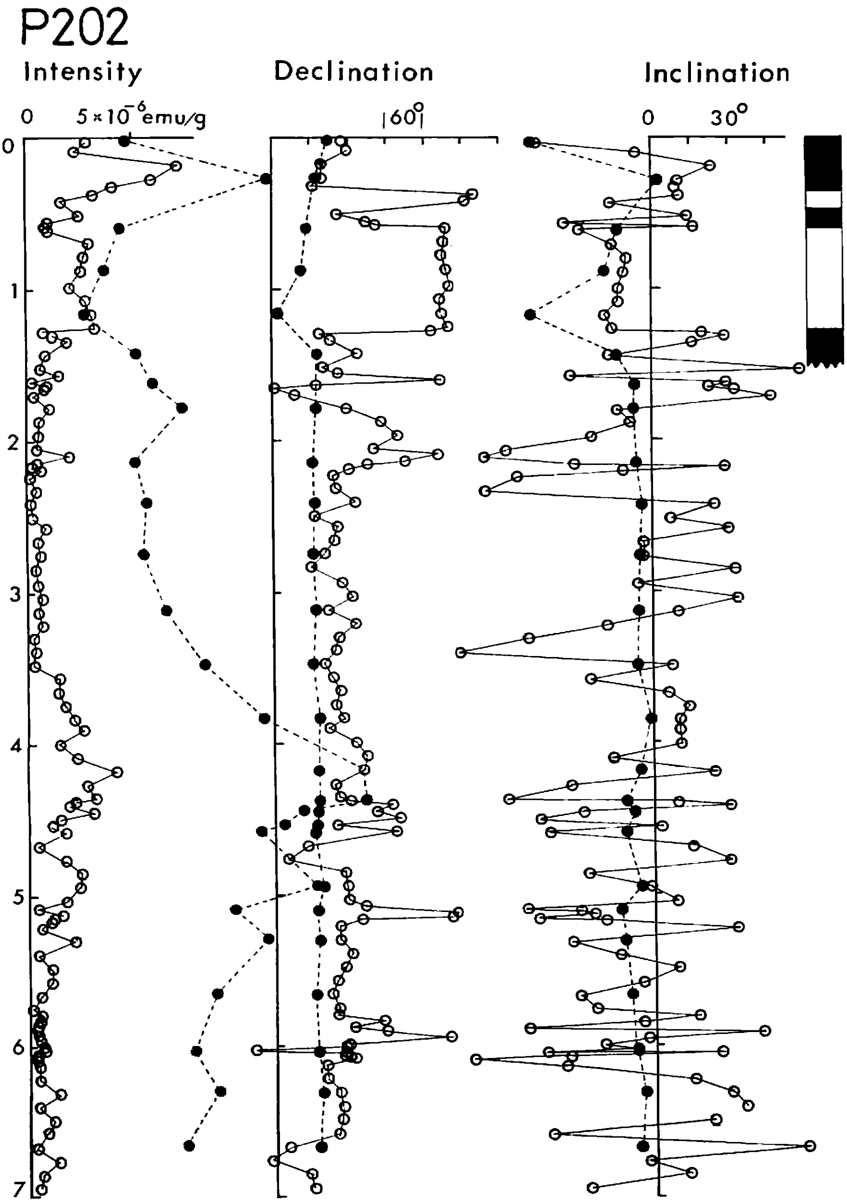

P201
Intensity
Declination
Inclination
0
1×10⁻⁵emu/g
160°
0
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (10)



P202
Intensity
Declination
Inclination
0
5×10⁻⁶emu/g
160°
0
30°
0
1
2
3
4
5
6
7

Fig. X-3 (11)

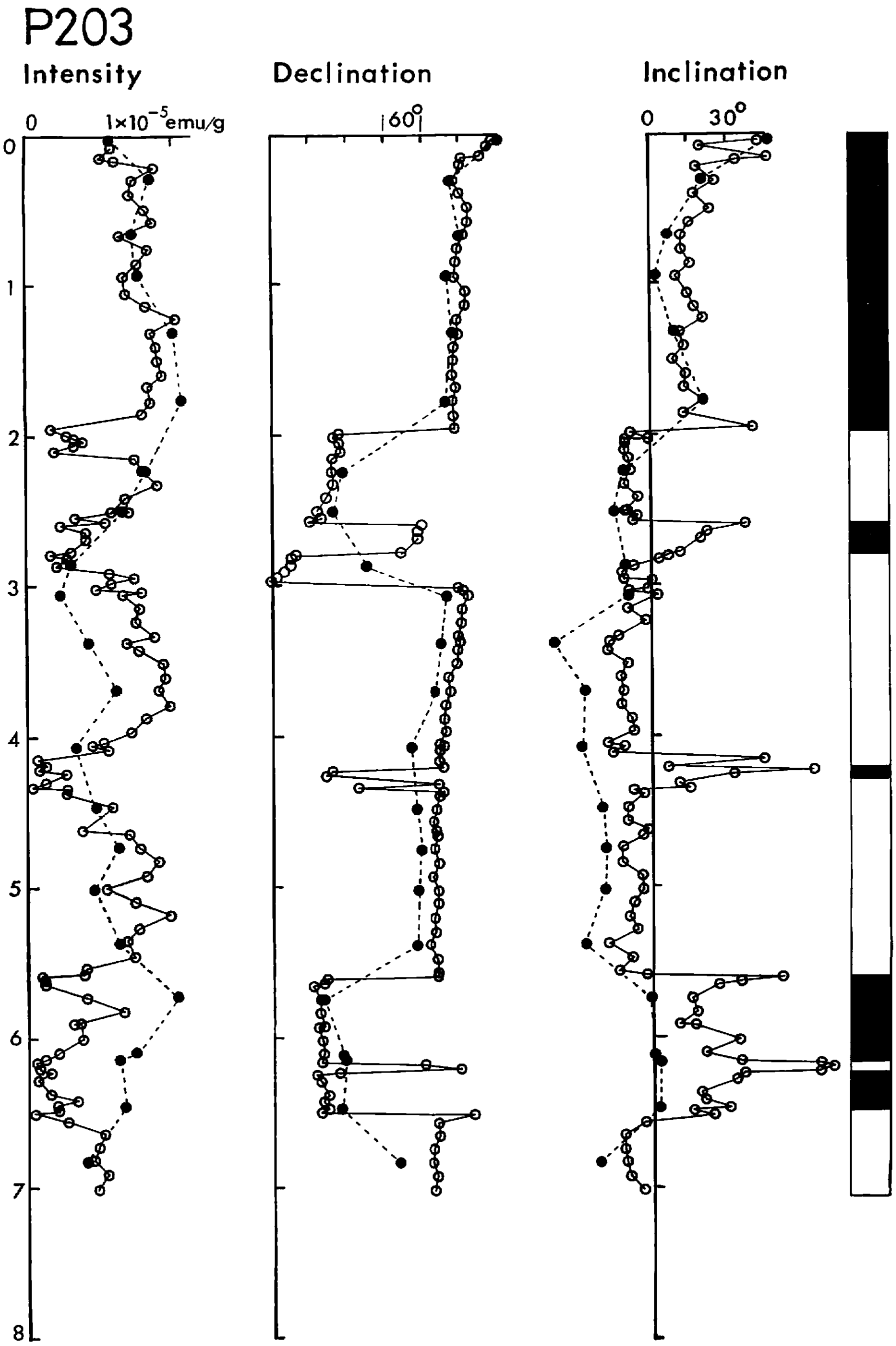

P203
Intensity
Declination
Inclination
0
1×10⁻⁵emu/g
160°
0
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (12)

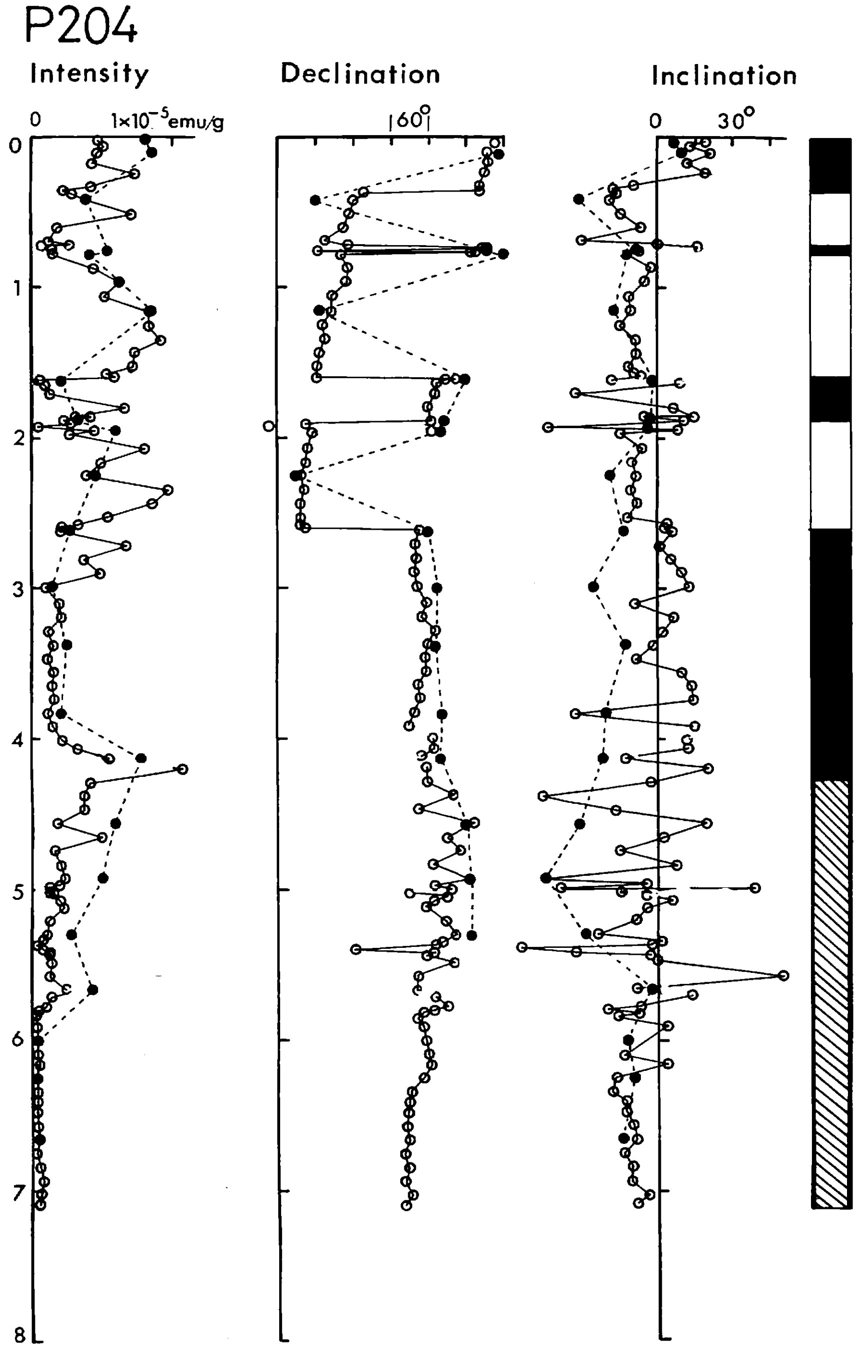

P204
Intensity
Declination
Inclination
0
1×10⁻⁵emu/g
160°
0
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (13)

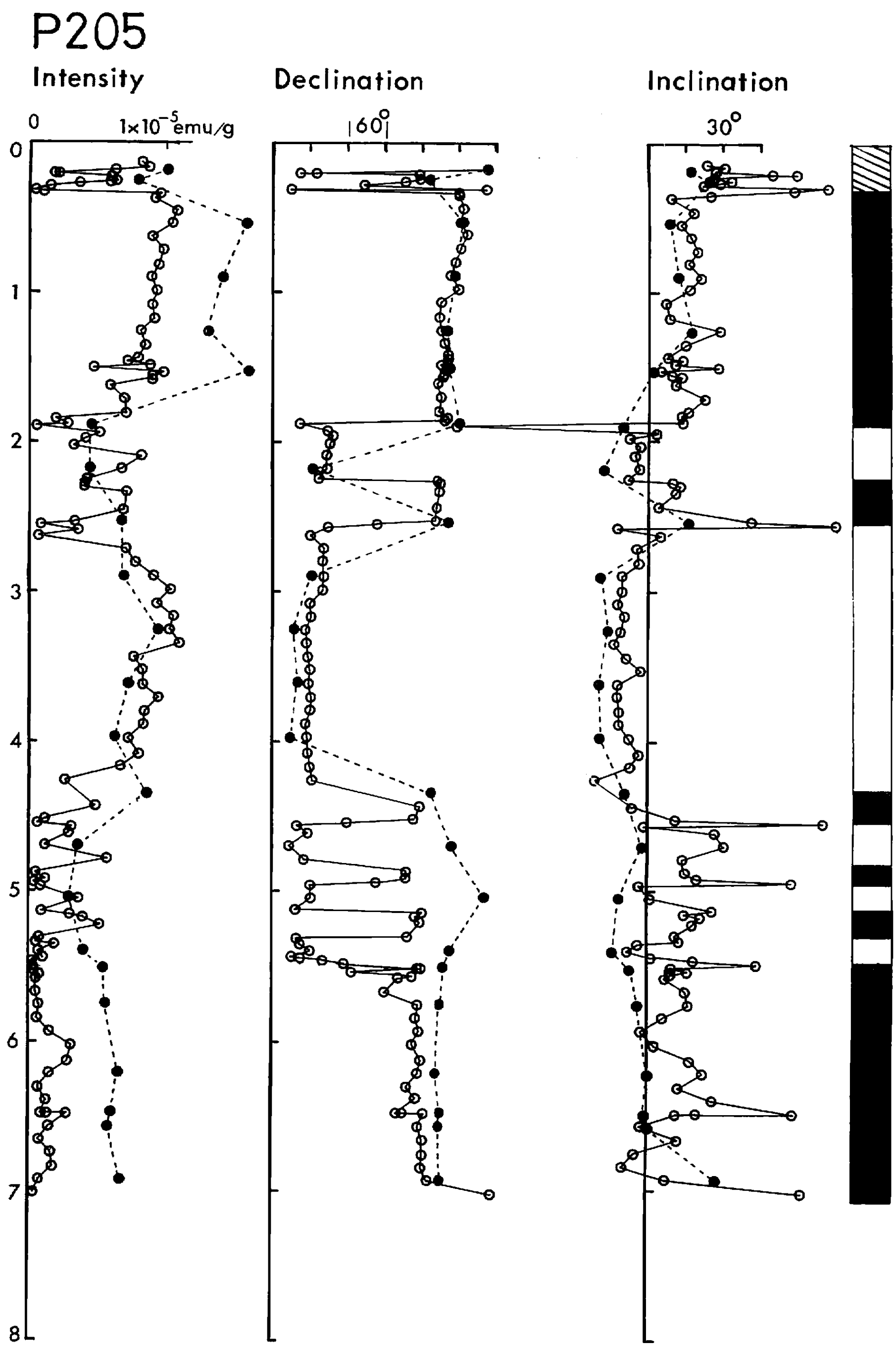

P205
Intensity
Declination
Inclination
0
1×10⁻⁵emu/g
160°
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (14)

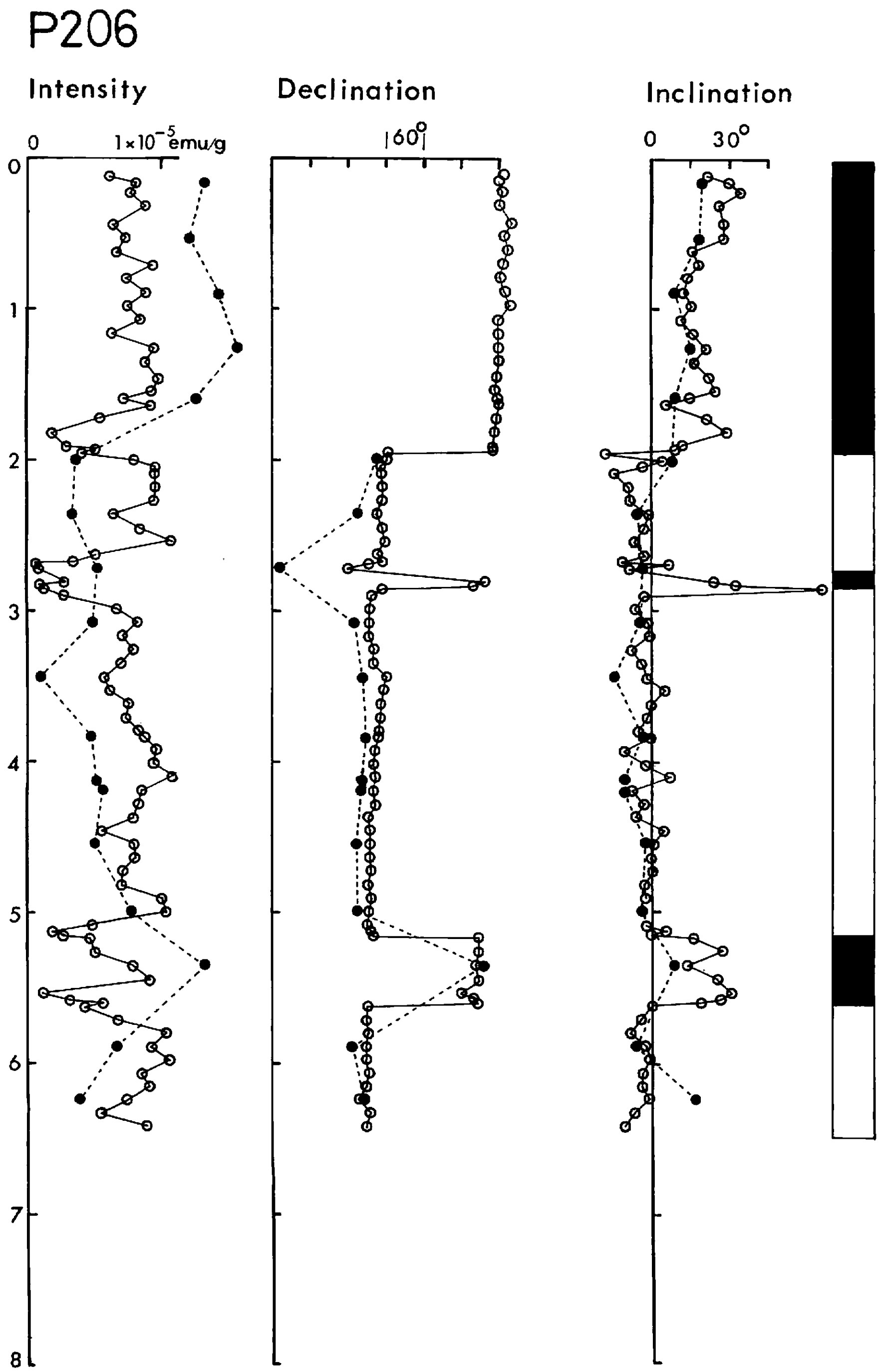

P206
Intensity
0
1×10⁻⁵ emu/g
Declination
160°
Inclination
0
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (15)

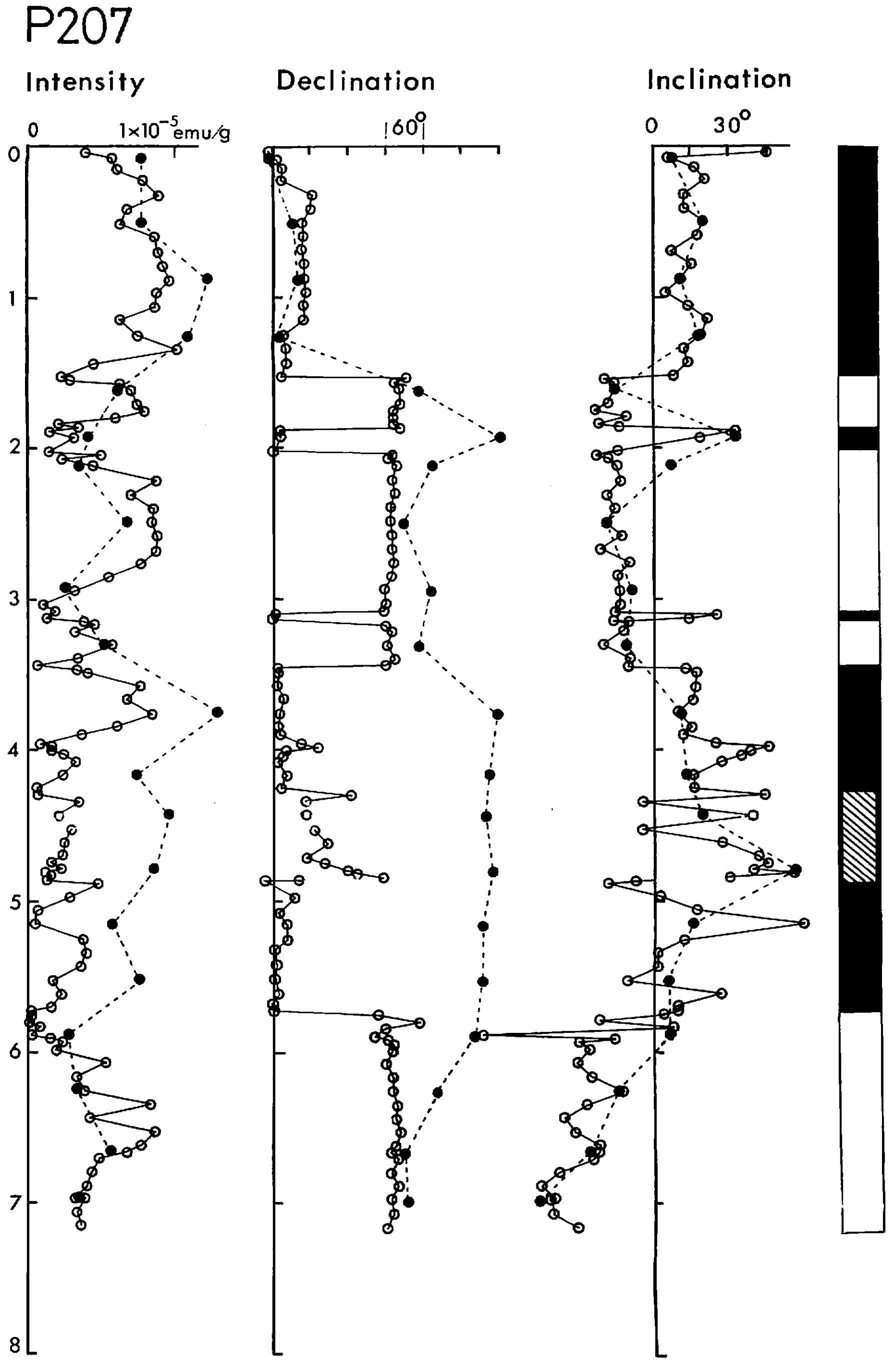

P207
Intensity
Declination
Inclination
0
1×10⁻⁵emu/g
160°
0
30°
0
1
2
3
4
5
6
7
8

Fig. X-3 (16)

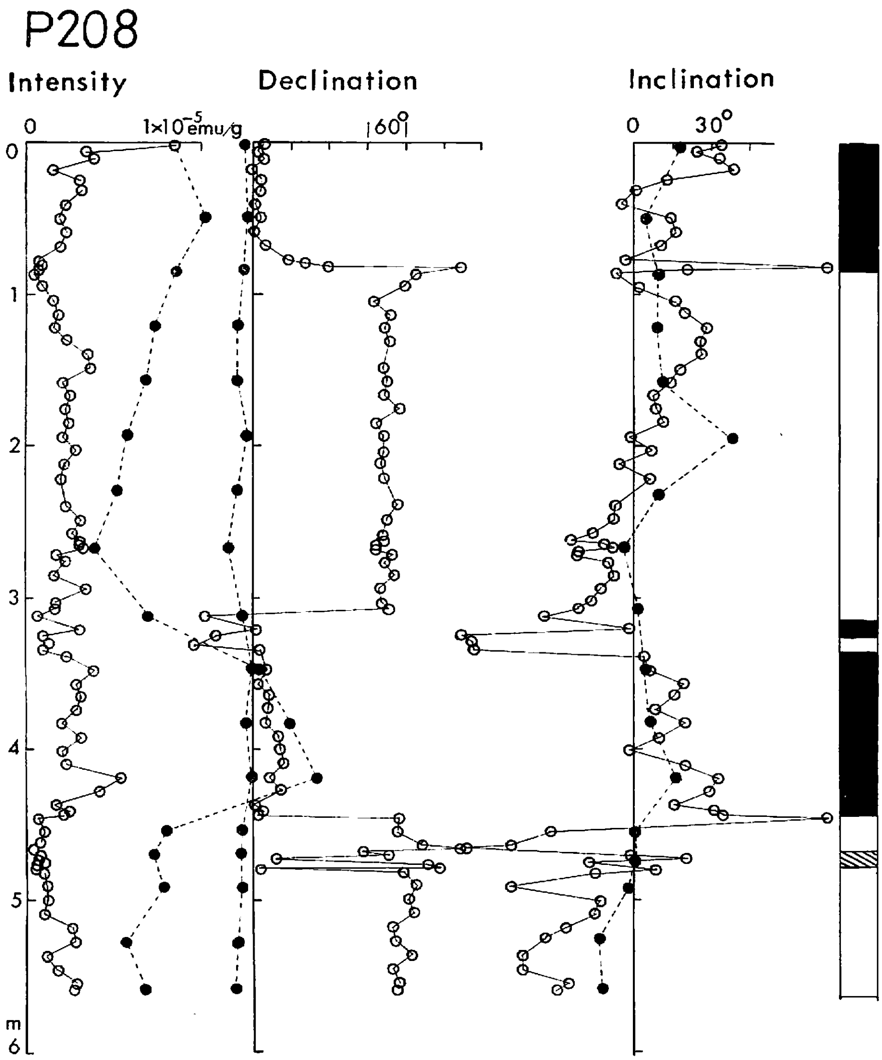
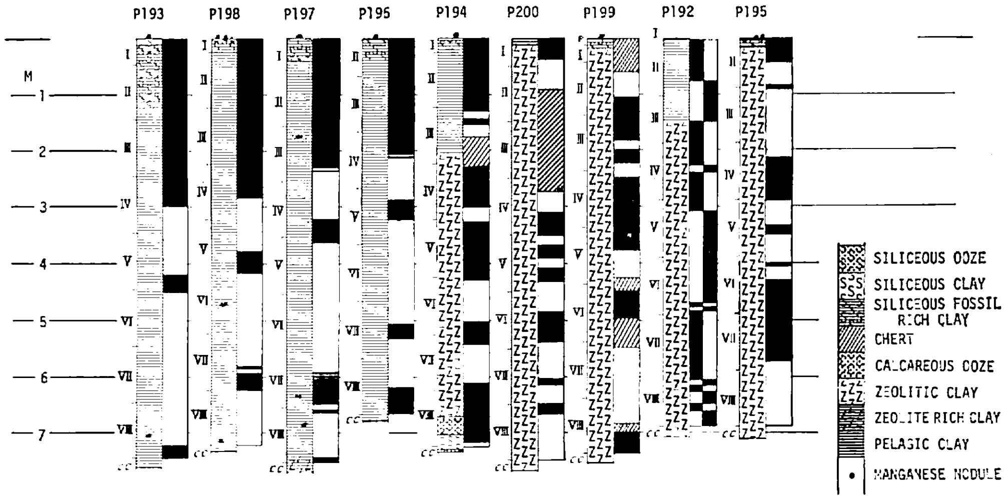


Fig. X-3 (17)

The cores sampled at relatively shallower area (5,500–5,700 m), such as P193, P196, P197, P198, and P206 showed stable remanent magnetization and their contents were pelagic clay. In detail, the cores can be grouped into those correspond to topographic areas as follows.

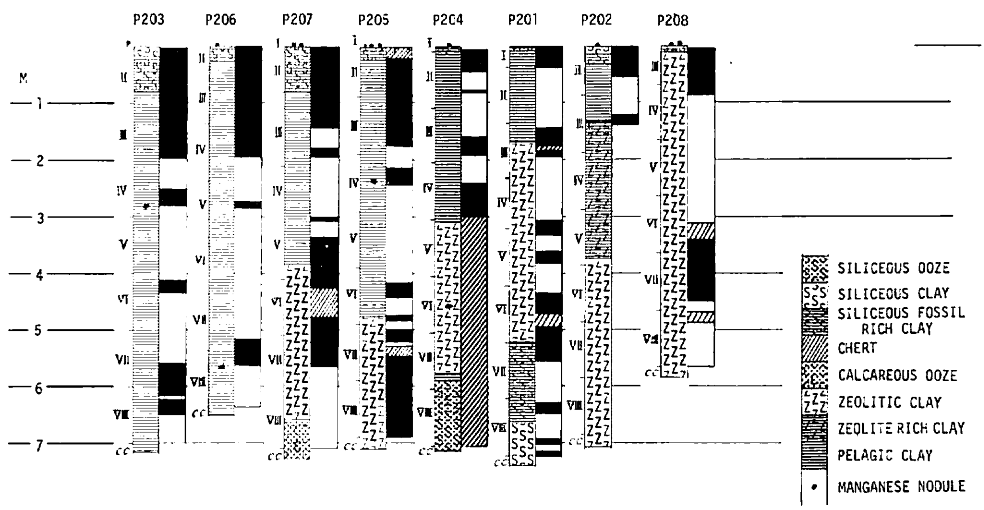
In No. 1 detail survey area, (I). cores on the northern small hills (height is about 400 m); P193, P194, P196, P197, and P198. (II). cores in southeastern deep basin part; P192, P195, P199, and P200.

In No. 2 detail survey area, (III). cores in northern deep basin part which continues from the same type area of No. 1 area; 201, P202, P204, and P208. (IV). core on northern high area of the Magellan Trough; P206. (V). core in the bottom of the trough; P205. (VI). cores in the southern deep basin out of the southern high



PISTON CORES IN DETAILED SURVEY AREA I

Fig. X-4 (1)



PISTON CORES IN DETAILED SURVEY AREA II

Fig. X-4 (2)

Fig. 4(1, 2) Summarized magnetostratigraphic pattern and lithology.

area of the trough; P203 and P207. The description of each core is given below.

Detail description of cores in each area

Northwestern hill in the detailed survey area I

P193 The sedimentation rate curve in Fig. 4 shows good linearity and it suggests the continuous sedimentation throughout the core. the lowest normally magnetized part seems to correspond to Olduvai event. Its sedimentation rate is then calculated to be 4.41 mm/1000 year between the end of Olduvai event (7.2 m) and the beginning of Brunhes epoch (3 m).

P194 This is located in the boundary area of northern hills and deep sea basin. Its uppermost part shows continuous sedimentation from 1.9 m to 0 m, and seems to correspond to the age between a little before Jaramillo event and present (1.0 Ma and 0 Ma). The lower part than 2 m shows weaker intensity and lower stability of remanent magnetization than that of upper part, especially having fluctuation in inclinations. Furthermore, there are found late Eocene radiolarians in the lowest part of the core, and there are early Eocene—early Oligocene ichthyoliths between 4.5 m and 6 m. (NISHIMURA, Chapter VII in this cruise report) So there might be a hiatus at around 2 m. The lower part is estimated to be 37.6 Ma to 36.5 Ma taking the ichthyoliths age into consideration. But then the sedimentation rate seems to be a little higher, and and it is calculated to be triple of uppermost part. The sedimentation rate of uppermost part is calculated to be 1.65 mm/1000 year between the beginning of Jaramillo event and present, while that of lower part is 4.77 mm/100 year.

P196 Its top 0.5 m part contains siliceous clay while all other remaining core is composed of pelagic clay and continuous sedimentation is expected. The uppermost normally magnetized part (0 m to 2 m) is thought to be Brunhes epoch, second one (3.9 m to 4.2 m) is Jaramillo event, third one (5.1 m to 5.3 m) is Olduvai event, and lowest one (lower than 6.1 m) is a part of Gauss epoch. Then the part of Olduvai event is too short comparing with that of Jaramillo event and it is thought that the sedimentation rate may have changed between the end of Olduvai event and the beginning of Jaramillo event. This core seems to reach to near Kaena event in Gauss epoch and the age of the bottom is estimated to be 2.6 Ma. The sedimentation rate is calculated to be 2.51 mm/1000 year between the end of Gauss epoch and present.

P197 This core resembles to P196 in the most part from top to 6 m and continuous sedimentation is expected, but the lowest 1 m contains zeolitic clay and it may be old, so it is uncertain if the lowest normally magnetized part is the end of Gauss epoch. The characteristic feature of this core is small reversals in the boundary between Brunhes and Matuyama epoch and in the end part of Olduvai event. The short normal part below Olduvai event (at 6.6 m) may be Renuion event. The core has three horizons of buried Mn-nodules at 1.7 m, 6.2 m, and 6.9 m, respectively. If it is assumed that bioturbation causes the pushing-up of Mn-nodule's and the change of sedimentation rate causes burial of Mn-nodules, the small event like reversals in the magnetic boundary layer may be caused by bioturbation. The core has radiolarians of middle Miocene in its core catcher and there seems to be hiatus between the lowest part and the part of the core catcher.

P198 This core also resembles to P196 and continuous sedimentation is expected. The lowest part is inferred to be just after the end of Gauss normal epoch as in the same way in P196 and P197, and the age of the bottom is estimated to be 2.2 Ma from its magnetic pattern. It has small normally magnetized part at 5.8 m and may correspond to Gilsa event. The core has Mn-nodules at 4.8 m which corresponds to the age between the end of Jaramillo event and Olduvai event and also at 7.1 m which does the age between the beginning of Olduvai event and the end of Gauss poch.

The deep basin in the detailed survey area I

P192 The core has pelagic clay only in the top 1.2m and the lower part is all composed of zeolitic clay. The inclination of remanent magnetization is higher than the expected ones by 30 degrees in each part, suggesting that the piston corer might not penetrated the sediment vertically. But it is unknown that piston corer can penetrate sediments with such high inclination as 30°. The intensity of top part is weak and the top part may not correspond to Brunhes epoch. Furthermore the inclinations are lower than those of the part between 0.7 m and 1.4 m whose declinations vary from those of upper one by about 180°, so the top part may be magnetized reversally. The core has discontinuity at about 1.3 m lithologically, but it is not clear magnetostratigraphically whether there is a hiatus in its boundary between pelagic clay and zeolitic clay.

P195 The top 5 cm (2 specimens) shows stable remanent magnetization and is thought to be normally magnetized, but the lower part between 0.05 m and 4.5 m shows weak and unstable remanent magnetization and lower part than 4.5 m shows meta-stable remanent magnetization. The top part is composed of fresh siliceous clay and beneath of it there is much zeolitic clay. Magnetic pattern of the core is not fitted to the standard magnetic stratigraphy of Pleistocene or Pliocene so it seems to be old and it is thought that there is a discontinuity near the top. The lower pattern resembles to that of standard magnetic stratigraphy between 19 Ma and 16.5 Ma, then the lowest reversally magnetized part is too long and there may be another discontinuity at 4.5 m.

P199 The intensity of remanent magnetization of the core is weak and unstable. Its content is nearly the same as P195 lithologically. Revised pattern of Fig. X–3(8) resembles to that of standard magnetic stratigraphy between 13.4 Ma and 12 Ma but the high inclination values can not be explained.

P200 The top 0.5 m shows stable remanent magnetization but the lower part shows fluctuated pattern, and it is difficult to decide magnetic direction of the part of the core. The part between 1 m and 2 m shows most unstable remanent magnetization.

The northern deep basin in the detailed survey area II

This area is a northwestern continuation from deep basin in the detailed survey area I, and the topographic type is similar to the southern deep basin in the detailed survey area I.

P201 Intensity of remanent magnetization is stable in top 1.7 m. This part may correspond to the age between Gauss epoch and present. The lower part than 1.7 m shows weak intensity and stability. In its lowest part there are radiolarians of middle Miocene, so its lower part may correspond to the age between 15 Ma and 12 Ma. On the other hand, its magnetic pattern resembles to that of the age between 6.8 Ma and 3.9 Ma. Anyway there seems to be a hiatus at 1.7 m, where lithology of sediment changes from pelagic clay to zeolitic clay, and the magnetic pattern of the upper part resembles to that of the age between 2.1 Ma and 0 Ma. If it is right that the second normal part in upper part (between 1.5 m and 2.0 m) is Olduvai event, the sedimentation rate of upper part is calculated to be 1.12 mm/1000 year. The sedimentation rate of lower part is calculated to be 1.7 or 1.5 mm/1000 year, if its age is between 15 Ma and 12 Ma, or 6.8 Ma and 3.9 Ma, respectively.

P202 The uppermost 1.4 m shows stable remanent magnetization and it seems to correspond to a part of standard magnetostratigraphy between 2.0 Ma and 0 Ma. There might be a continuous sedimentation from that time. But the lower part than 1.4 m has weak and unstable remanent magnetization and its orientation fluctuates much. There may be a discontinuity at 1.4 m.

P204 The upper 3 m shows clear pattern of remanent magnetization and it shows rotation of sample around z axis. The rotation appears continuously from top to 3 m and its total is 120°. Its magnetostratigraphic pattern resembles to the part of standard one between the end of Gauss normal epoch and present (2.6 Ma and 0 Ma). The direction of magnetization of lower part shows the same direction but its stability is not good. According to micropaleontologic data the lowest part has radilarians of lower to middle Miocene. It may correspond to the longest normally magnetized age, 20.1 Ma to 19.0 Ma, in lower and middle Miocene, because the normally magnetized part of the core continues for the range of 4 m. If sedimentation rate is 1 mm/1000 year, then it is needed a time of 4 Ma for deposition of 4 m thick sediment.

P208 The top 0.05 m shows stable remanent magnetization, but the remanent magnetization of lower part does weak intensity and stability. Although magnetostratigraphic pattern is recognized, it is difficult to show the relation between the magnetostratigraphic pattern of the core and standard one, because there is no available micropaleontologic data.

The high area north of Magellan Trough

P206 The core consists of top siliceous clay of 0.3 m and pelagic clay from 0.3 m to bottom. There is a good coincidence between the magnetostratigraphic pattern of the core and standard one. The normally magnetized part between 0 m and 1.9 m is then Brunhes epoch, short normally magnetized one at 2.7 m is Jaramillo event, and the lowest normally magnetized part between 5.1 m and 5.6 m is Olduvai event. There is a small Mn-nodule at 5.5 m and the age of the horizon is in earlier half of Olduvai event.

The bottom of Magellan Trough

P205 The uppermost 0.2 m shows fluctuated magnetic orientation. Because its intensity and stability is strong enough, the fluctuation may not be caused by weak intensity nor low stability which appears usually in zeolitic clay, but it may be caused by a small slump and then disturbance of sediments. The magnetization of the core between 0.2 m and 5.3 m shows strong intensity and good stability but the lower two normally magnetized parts cannot be explained by the assumption of continuous sedimentation. So there may be a discontinuity at the depth of 4.5 m. Then it may be said that sedimentation have continued from the age of 1.7 Ma years ago to present and the short normally magnetized part at 4.3 m is perhaps Olduvai event, and the sedimentation rate is calculated to be 2.62 mm/1000 year between the end of Olduvai event and present. The lower part than 4.5 m is composed of zeolitic clay and it is difficult to infer the age from the magnetostratigraphic pattern. The two short normally magnetized parts may be events in Gilvert epoch then there seems a short hiatus of about 2 Ma at 4.5 m. It may correspond to the age between 10.0 Ma and 8.6 Ma if there is no discontinuity at 5.4 m but is at 4.5 m. The core has a Mn-nodule at 2.3 m and the age is estimated to be in Jaramillo event.

The deep abyssal plane south of Magellan Trough

P203 The core consists of siliceous clay in top 0.8 m and pelagic clay in remaining lower part, and it seems to show continuous sedimentation from bottom to top. According to the results of measurement of remanent magnetization the orientation of remanent magnetization rotates by 180° in the part between 2.3 m and 3.2 m. It seems to be caused by the rotation of upper or lower sediment. Other than that there is a rotation of magnetic declination by 60° at 0.2 m and it seems to be caused usual disturbance in the top of the core. Continuous sedimentation might have occurred from bottom to top and it may correspond to the age between the end of Gilbert epoch and present. Sedimentation rate calculated from the interval between the beginning of Jaramillo event and present (0.97 Ma and 0 Ma) is 2.87 mm/1000 year and 1.02 mm/1000 year in the interval of Gauss normal epoch (from 3.4 to 2.47 Ma) and it seems to show greater rate of sedimentation as the age is younger.

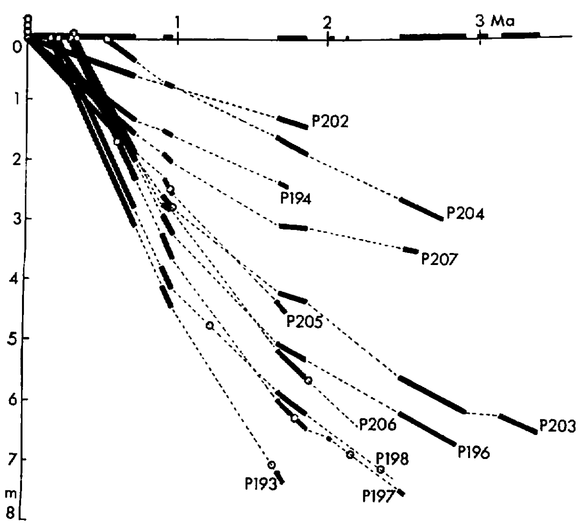


Fig. X–5 Sedimentation rate curves decided from magnetic stratigraphy assuming that there is no hiatus after the late Pliocene.

P207 The contents of the core is top siliceous clay of 0.7 m, pelagic clay of the interval between 0.7 m and 3.7 m, zeolitic clay in the interval between 3.7 m and 6.7 m, and lowest calcareous nanno ooze of 0.5 m. The remanent magnetization of upper 3.7 m shows strong intensity and stable remanent magnetization and it seems to have deposited continuously. The lower part than 3.7 m shows unstable remanent magnetization and it is difficult to infer the age from only one inversion of orientation of remanent magnetization in the lower part, although the lowest calcareous nanno ooze gives their age as Oligocene. The upper 3.7 m may correspond to the age between the end of Gauss epoch and present. Then the sedimentation rate is calculated to be 2.09 mm/1000 year between the end of Jaramillo event and present, and 0.58 mm/1000 year between the end of Gauss epoch and the end of Olduvai event.

Discussion

Sedimentation rate curves of all cores whose contents are siliceous clay and pelagic clay are shown in Fig. X–5. The lower part whose component is zeolitic clay and their age seems to be old is omitted in this figure. Generally speaking, the sediments in areas shallower than 5,850 m such ones as on the small hills is composed of pelagic clay through out the core, and their sedimentation rate is high, except for P205 which is in the bottom of Magellan Trough. The cause of high sedimentation rate in shallower areas may be caused from the relation between bottom water current and

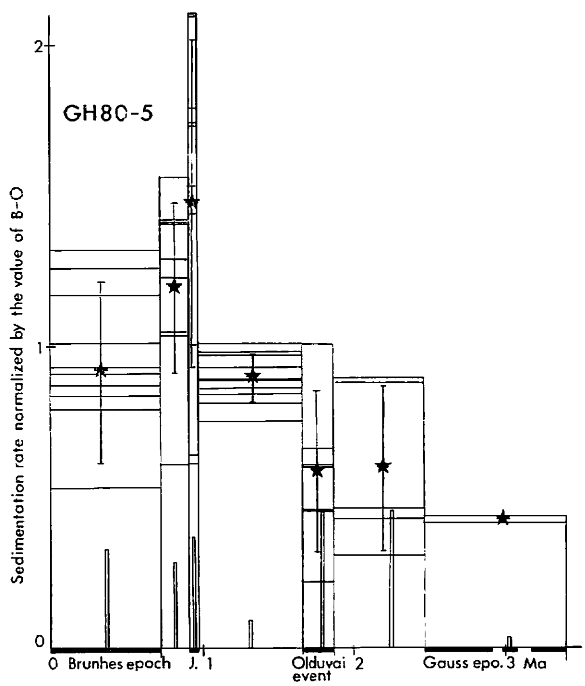


Fig. X–6 Sedimentation rate curve plotted against age. The values are normalized by the sedimentation rate between the end of Olduvai vent and the end of Matuyama epoch.

topography. Sedimentation rate in average seems to have changed from approximately 1 mm/1000 year to 3 mm/1000 year from 2.0 Ma ago to present. The sedimentation rate calculated in each interval of magnetic invertion and normalized ones using the sedimentation rate between the end of Olduvai event and the beginning of Brunhes epoch are shown in Table 2 and Fig. X–6. Sedimentation rate seems to have changed slow to high from Gauss epoch to Jaramillo event and after the peak of Jaramillo event it seems to have decreased to present. But the fluctuation of sedimentation rate in each core is high and particularly it might be more frequent in each interval of magnetic inversion.

There seems to be a hiatus between the part where magnetic properties of remanent magnetization is strong and stable and the one where the properties is weak and unstable. This fact is evidenced by abrupt change of magnetic properties, although there is a doubt of change of chemical condition at the depth. Furthermore there is a change of lithology from zeolitic clay to pelagic clay near at the depth of change of magnetic properties. The cause of the change of magnetic properties may be erosion. There might be many times of erosion of various scale and in some time almost all area may have been eroded to some extent. In the same way there might be a small scale erosion whose level is changed by topographic parameter just before the deposition of top siliceous clay.

P194 shows hiatus before the age between Jaramillo event and Olduvai event, P202 and P205 show hiatus before the age around Olduvai event, and P204, P207 show hiatus before the age in Gauss epoch. There may be strong erosion during such ages and some of the cores may indicate existence of such erosion and occurrence of older sediments in the upper horizon of the cores.

Mn-nodules occur in several cores. The cause of buried Mn-nodules may be that they have not been kept to the surface of sediment. Generally speaking, a large percent of Mn-nodules occur on the surface of the sediments, and they are thought to have been uplifted continuously by some unclarified effect, as those of benthonic animals. The histogram of sedimentation rate shows high rate around Jaramillo event and coincidently there occur buried Mn-nodules in that age in P205 and P203. Other than that, P197 shows large Mn-nodule in the beginning of Brunhes epoch and the cause may be that the Mn-nodules in this core had grown up although ones in other cores had been buried, but it had been buried after its growth too large to be uplifted to the surface of sediment. Also there are Mn-nodules around Olduvai event in P193, P197, and P206. The cause may be the same as mentioned above. The variation of sedimentation rate may be caused by the same cause of hiatus, such as a hiatus, and it may have made many hiatuses shown in each core causing variety of sedimentation rates, due to its level of erosion.

The calculated sedimentation rate between Jaramillo event and Brunhes-Matuyama boundary must cause 120 to 300 thousand year blank in the top of cores. This may be caused by disturbance of top part in piston corers, or may be caused by erosion in recent year, which is not so strong and it did not erode all new sediments which had deposited after the former strong erosion.

References

JOSHIMA, M. (1982) Remanent magnetization of piston cores from the Wake-Tahiti transect in the Central Pacific Basin. *Geol. Surv. Japan Cruise Rept.*, no. 18, p. 276–287.

STACKELBERG, U. (1982) Influence of hiatuses and volcanic ash rains on the origin of manganese nodules of the Equatorial North Pacific (Valdivia cruises VA-13/2 and VA-18). *Marine Mining*, vol. 3, p. 297–314.

WINTERER, E. L. (1973) Regional problems. *Initial Report of the Deep Sea Drilling Project*, vol. 17, Washington (U.S. Government Printing Office), p. 911–922.