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PALYNOFACIES STUDIES AT THE DUNLIN-BRENT TRANSITION, NORTHERN NORTH SEA.x)

As part of the project presented by Jenö Nagy in a previous talk today, kerogen analysis has been carried out on conventional cores from the Brent and Dunlin formations in the northern North Sea. Here I would like to concentrate on the development at the Dunlin-Brent transition, dealing with the Drake, Broom and Rannoch Members. But first some comments on the kerogen analysis itself.

Kerogen analysis may be defined as classification and quatification of plant debris in sedimentary rocks. Plant debris in sedimentary rocks represents only a selection of the most resistant material produced by vegetation. The categories applied in kerogen analysis are partly botanically and partly just morphologically defined.

The plant debris within the studied interval is referred to six different categories. Marin and terrestrial palynomorphs are both well defined morphologically and botanically and so are the membraneous material which is mainly originating from plant cuticle.

The wood category is more heterogeneous, representing lignified tissues and cortex. It is possible to separate between several types of wood material, but this has not been done here. Tracheidal and fibreous fragments are, however, characteristic for the wood material in most samples.

x) This talk was given by T.Bjærke at the Norwegian Petroleum Directorate meeting 3.-4.3 1983. Well 34/10-1 was not identified due to confidentiality.

Inertinite represents all fragments appearing opaque in transmitted light. It is composed mainly of oxidized wood material. Thermally altered reworked material may also contribute to this category.

The last category, which is here termed finely dispersed debris, is the most heterogeneous. All types of plant debris may theoretically contribute to this category. I will not here go into the techniques applied to establish the source of this finely fragmented debris, just say that the bulk of finely dispersed debris present in the samples studied is originating from degradation and fragmentation of terrestrially derived material.

Two additional kerogen categories are also used in our standard kerogen analyses, but they are either absent or only sporadically present in the studied samples.

Regarding quantification the amount of finely dispersed debris is estimated relatively to all other components from strew mounts of the total kerogen assemblage. The relative amount of all other categories is estimated semiquantitatively or quantitatively by counting from the assemblage remaining after screening through a 20 micron nylon net.

Four wells have been selected to demonstrate the development across the Dunlin-Brent transition. These are 33/9-3, 33/9-9, 33/12-4 and 34/10-1.

The uppermost part of the Drake Member, the Broom Member and the lower part of the Rannoch Member have been correlated on the basis of palynology (Fig. 1). A 15 to 20m thick sequence from each well is included in this presentation.

From Well 33/9-3 the kerogen composition within the upper Drake Member shows a high stability with abundant finely dispersed debris, common inertinite, common to abundant wood fragments and abundant membraneous material (Fig. 2). Palynomorphs are relatively abundant, marine components making up 15% of the screened assemblage, spores and pollen of terrestrial origin constituting approximately 10%.

This kerogen composition is characteristic throughout the Drake Member showing a shallow marine near shore environment dominated by terrestrially derived material. High stability in assemblage composition shows only small variations in sedimentary environment through this interval. A slight regressive development is, however, seen towards the top of the unit.

By the deposition of the Broom Member characteristic changes take place with reduction in marine components and an increase in terrestrial palynomorphs and membraneous material. The kerogen assemblage is poorly sorted.

In the lower part of the Rannoch Member there is a significant maximum in the dinoflagellate species Nannoceratopsis gracilis. This component is rapidly reduced upwards. The amount of terrestrial palynomorphs is established on a considerably higher level, making up between 20 and 30 percent of teh screened assemblage, but a rapid reduction is observed when going up into the sandstones of the Rannoch Member.

Membraneous material shows two maxima in the lower part of the interval and is then gradually reduced to less than 10% towards the base in the sandstones.

Inertinite and wood varies inversely as they are the far most abundant types of debris within the interval. In the upper part of the interval they make up more than 70% of the debris, and within the sandstones of the Rannoch Member, inertinite makes up more than 90% of the assemblage, probably present within the sediment as charcoal clasts, a result of extreme sorting.

The Broom Member represents a sudden increase in poorly sorted terrestrial debris. Above this level shales of the Rannoch Member were deposited in a restricted marine or brackish environment with reduced circulation. A biologically controlled bloom of the dinoflagellate Nannoceratopsis gracilis occurs within this environment.

A general increase in energy upwards causes gradually increased sorting of the plant debris resulting in the following characteristic pattern: reduction in Nannoceratopsis gracilis followed by a reduction in membraneous material, then reduction in terrestrial palynomorphs and finally reduction in wood material ending up with a total dominance of inertinite.

In Well 33/9-9 the kerogen composition within the Drake Member is closely similar to that observed in 33/9-3 with common marin and terrestrial palynomorphs, common membraneous material and abundant wood and intertinite (Fig. 3). Finely dispersed debris, however, is reduced compared to 33/9-3 in this interval. High stability in kerogen assemblage composition and dominance of terrestrially derived plant debris also characaterize this locality. A slight regressive tendency is noted by reduction of marine palynomophs towards the top of the unit. Assemblages from the Rannoch Member are completely dominated by inertinite and wood, the other components already reduced to 15% or less. Again we note the pattern observed in Well 33/9-3 with the reduction in marine palynomorphs followed by reduction in membraneous material, then the amount

of terrestrial palynomorphs is reduced as inertinite and wood become totally dominating when going up into the sandstones.

Let us now turn to the condenced sequence present in Well 33/12-4 (Fig. 4). The Drake Member here seems to be represented by only 5 feet of grey shale. Through this interval a clearly regressive development takes place by an increase in wood and inertinite upwards. Terrestrial palynomorphs are abundant throughout, while marine palynomorphs are rare in the lower part and absent in the upper.

The Broom Member is here characterized by a strongly sorted assemblage dominated by inertinite; palynomorphs and mebraneous material being absent. In the lower part of the Rannoch Member just above the sandstone, marine palynomorphs reappear represented by Nannoceratopsis gracilis, terrestrial palynomorphs are abundant. Wood fragments dominate the assemblage. Further upwards we note a development corresponding to the pattern observed in the two other wells; disappearance of marine palynomorphs followed by disappearance of membraneous material, in the upper part increase in wood fragments and finally increase in inertinite. Rare terrestrial palynomorphs are still present in the uppermost sample studied.

The last sequence is from Well 34/10-1 (Fig. 5). The upper part of the Drake Member is again characterized by abundant to dominating inertinite and wood, and common terrestrial palynomorphs, Marine palynomorphs are rare. Samples from the fine grained sediments of the Rannoch Member are also dominated by wood and inertinite and common terrrestrial palynomorphs. In the lower part the dinoflagellate Nannoceratopsis gracilis is abundant, in the upper reduced to rare.

The same pattern as observed in Well 33/9-3 is partly reflected also in this well. A marginal, shallow marine environment dominated by terrestrially derived plant debris is established in the upper part of the Drake Member. An abrupt decrease in marine components is seen when going into the Broom Member, showing increased terrestrial input, and highly sorted assemblages in the sandstone horizons.

The fine grained sediments within the Ranroch Member contain abundant terrestrial debris and a significant bloom in the dinoflagellate species Nanoceratopsis gracilis, showing a restricted marginal marine or brackish environment. In the upper part of the member terrestrial input again increases and the relative amount of Nannoceratopsis gracilis is reduced.

Discussion

When comparing the information from the four wells presented here, a general pattern emerges. In addition, local differences in response to the general basin development are evident.

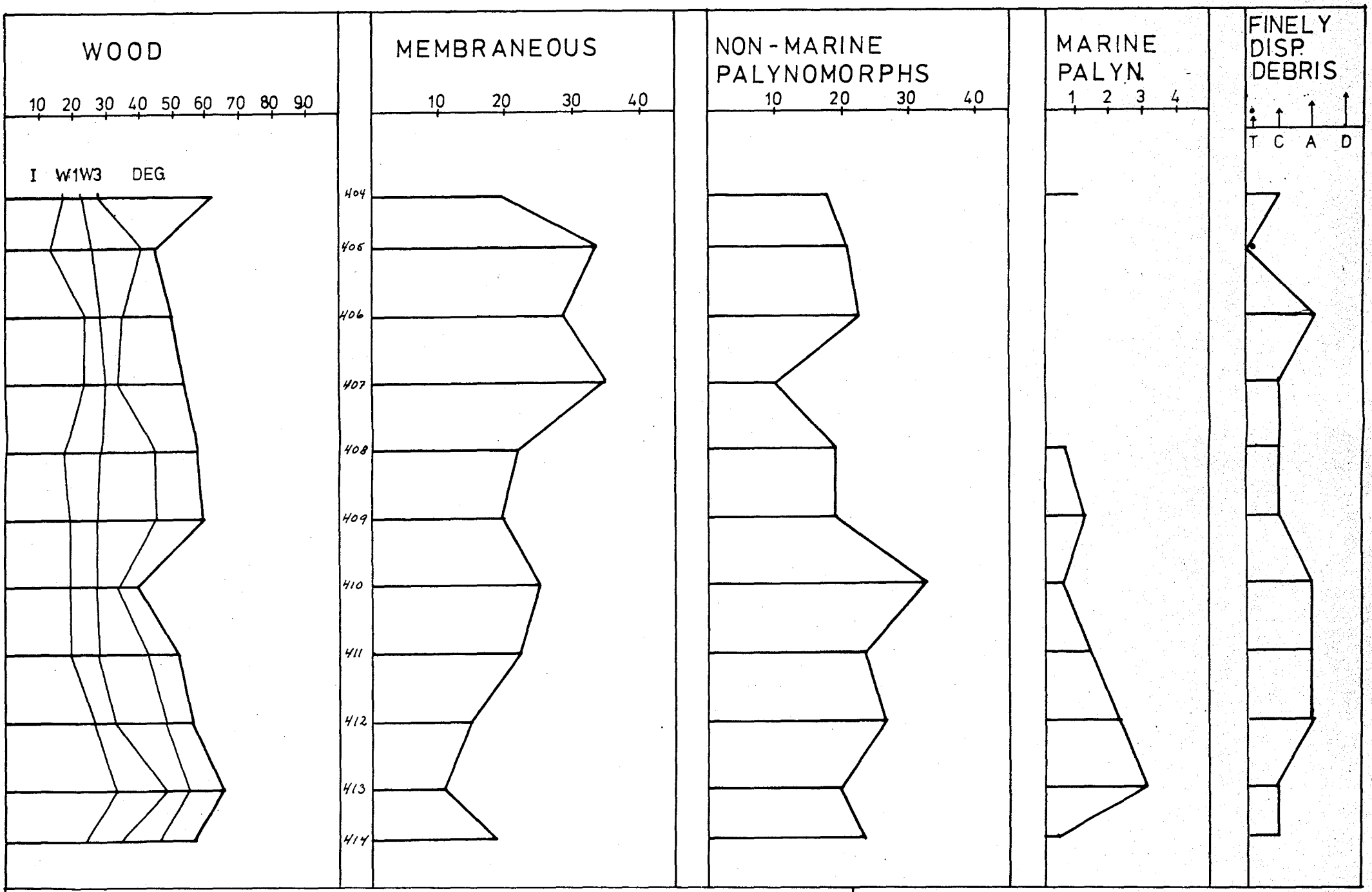
During the deposition of the Drake Member a marginal marine environment was established in all four wells. Kerogen assemblages from this interval are dominated by terrestrially derived debris. Towards the top of the Drake Member increased terrestrial input shows a regressive tendency. This development is most characteristic in Well 33/12-4, where strongly sorted assemblages are present in the upper part showing that this well occupies a more proximal position during the deposition of this unit.

The composition of the assemblages from the Broom Member shows a marked increase in terrestrial debris in all wells. In Wells 33/9-3 and 34/10-1 the assemblages are, however, poorly sorted, while 33/12-4 shows strong sorting indicating a higher energy and more shallow conditions here (Fig. 6).

The Rannoch Member represents a characteristic progradational sequence. In Wells 33/9-3 and 34/10-1 clays were deposited. Although the kerogen composition is very similar to that of the Drake Member, the abundance of Nannoceratopsis gracilis and excellent palynomorph preservation indicate a restricted marine or brackish environment, probably with reduced circulation. This environment was not established in Wells 33/9-9 and 33/12-4. These wells occupied a more proximal position, and a distal delta front facies was established above the Broom Member. This facies reached Wells 33/9-3 and 34/10-1 after the deposition of the clays described above.

The progradational development terminated by the proximal delta front facies represented by the strongly sorted assemblages dominated by inertinite and wood fragments seen in the uppermost samples studied.

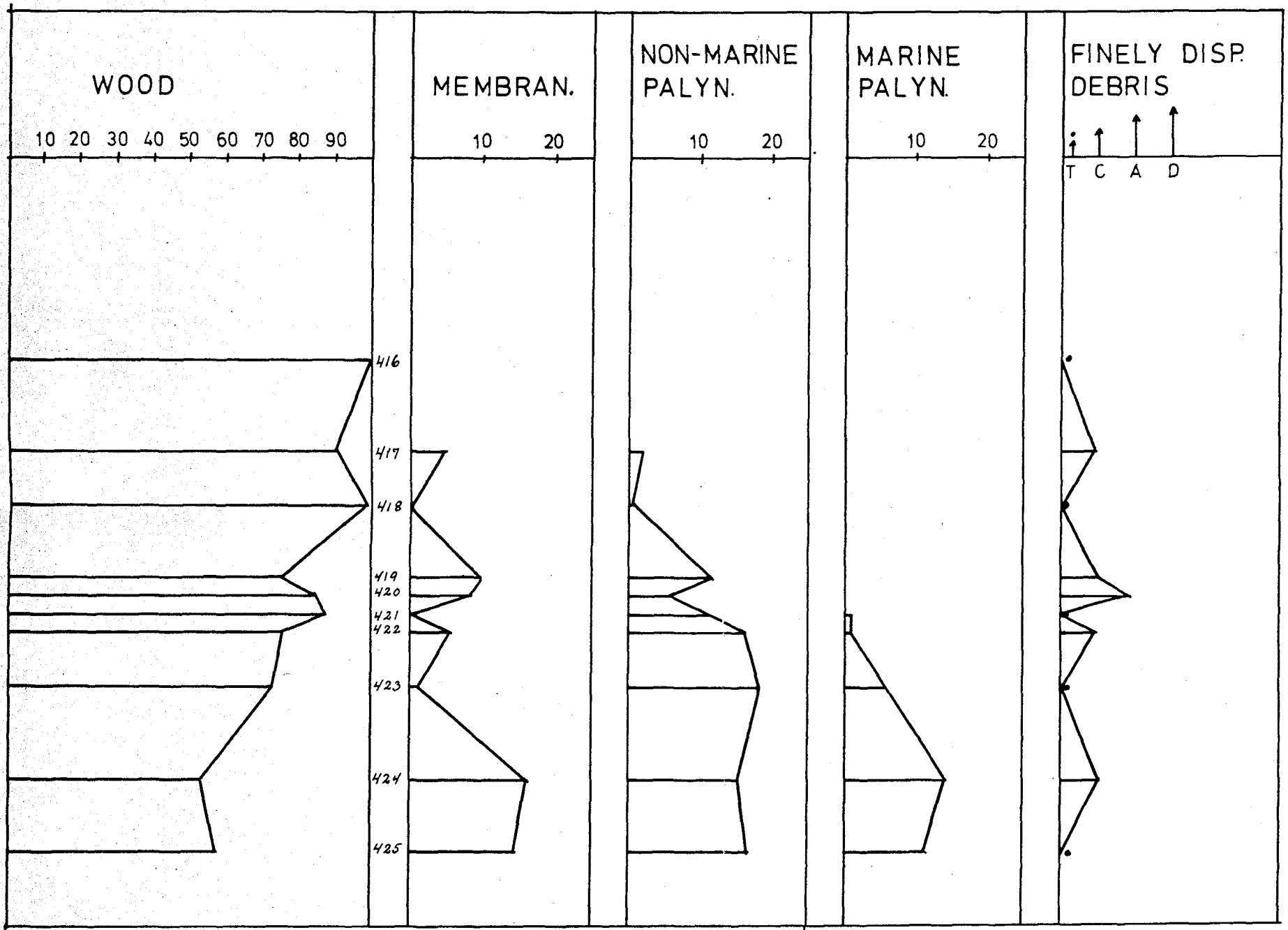
Tor Bjærke, LAP



ENCLOSURE 1

RESULTS OF KEROGEN ANALYSIS FROM WELL 33/12-2
(8655'- 8693') CORE 1

LAP

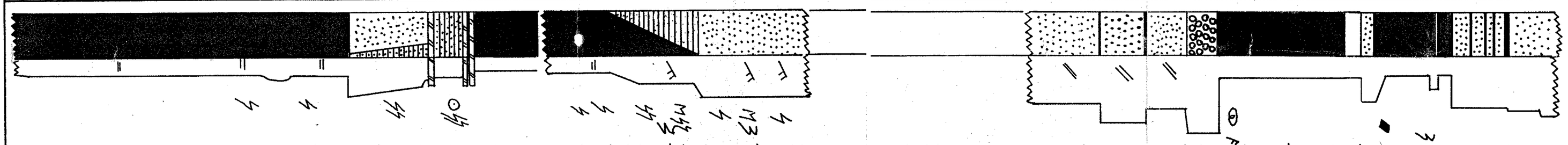


ENCLOSURE 3 RESULTS OF KEROGEN ANALYSIS FROM WELL 33/9-9 (2486.0m - 2516.6m.) CORE 7

LAP

"MIDDLE" PLIENSBACHIAN | LATE PLIENSBACHIAN | ?TOARCIAN | LATE TOARCIAN | LATE TOARCIAN - AALENIAN - ?BAJOCIAN

8925 8920 8915 8910 8905 8900 8895 8890 8885 8880 8875 8870 8865 8860 8855 8850 8845 8840 8835 8830 DEPTH IN FEET



SAMPLE DEPTH

8927 8923 8920 8917 8915 8913 8912 8910 8909 8907 8906 8901 8899 8896 8893 8890 8888 8887 8886 8884 8883 8878 8856 8849 8848 8846 8845 8842 8839 8837 8835 8833 8829 8827

- Deltoidospora minor
- Cerebropollenites mesozoicus
- Araucariacites australis
- Nannoceratopsis gracilis
- Quadraeculina anellaeformis
- Callialasporites dampieri
- Classopollis classoides
- Lycopodiumsporites austroclavatidites
- Klukisporites scaberis
- "Manumia"
- Michrhystridium spp.
- Comparodinium punctatum
- ? Parvocysta bullula
- Callialasporites turbatus
- Quadraeculina anellaeformis (Large)
- Kyrtomisporis sp.
- Annulispora sp.
- Chasmatosporites hians
- Duplexisporites problematicus
- Polycingulatisporites triangularis
- Callialasporites microvelatus
- Botryococcus
- Phallocysta eumekes
- Ricciisporites tuberculatus
- Tasmanites sp.
- Chasmatosporites apertus
- Stereisporites perforatus
- N.gracilis var.senex
- Polycingulatisporites cf.crenulatus
- Lycopodiacidites rugulatus
- Cerebropollenites cf.thiergartii
- Caytonipollenites pallidus
- Classopollis simplex
- Stereisporites sp.
- Comparodinium perpunctatum
- Kreuselisporites reissingerii
- Kyrtomisporis laevigatus

N.gracilis var.senex max.
K.reissingeri app.
C.perpunctatum app.
N.gracilis var.senex app.
N.gracilis max.
C. perpunctatum app.
N. gracilis app.

WELL 33/12-4 (8827-8927 ft.)

L.A.P.

STRATIGRAPHICAL DISTRIBUTION OF SELECTED PALYNOMORPHS

ENCLOSURE 5

WELL 33/12-4 (8827-8927 feet)
KEROGEN ANALYSIS

ENCLOSURE 6

LAP

LATE TOARCIAN - AALENIAN - ?BAJOCIAN

LATE TOARCIAN

?TOARCIAN

"MIDDLE" PLIENSBACHIAN

LATE PLIENSBACHIAN

DEPTH IN FEET

SAMPLE DEPTH

FINELY DISPERSED DEBRIS

INERTINITE

WOOD

MEMBR.

NON MARINE PALYNOMORPHS

MARINE PALYNOMORPHS

R C A D

8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925

8827 8829 8833 8835 8837 8839 8842 8845 8846 8848 8849 8856 8878 8883 8884 8886 8887 8888 8890 8893 8896 8899 8901 8906 8907 8909 8910 8912 8913 8915 8917 8920 8923 8927

ENCLOSURE 7

LAP

WELL 33/9-6 (3021 - 3031m)

KEROGEN ANALYSIS
CORE SAMPLES

Rare
Common
Abundant
Dominating

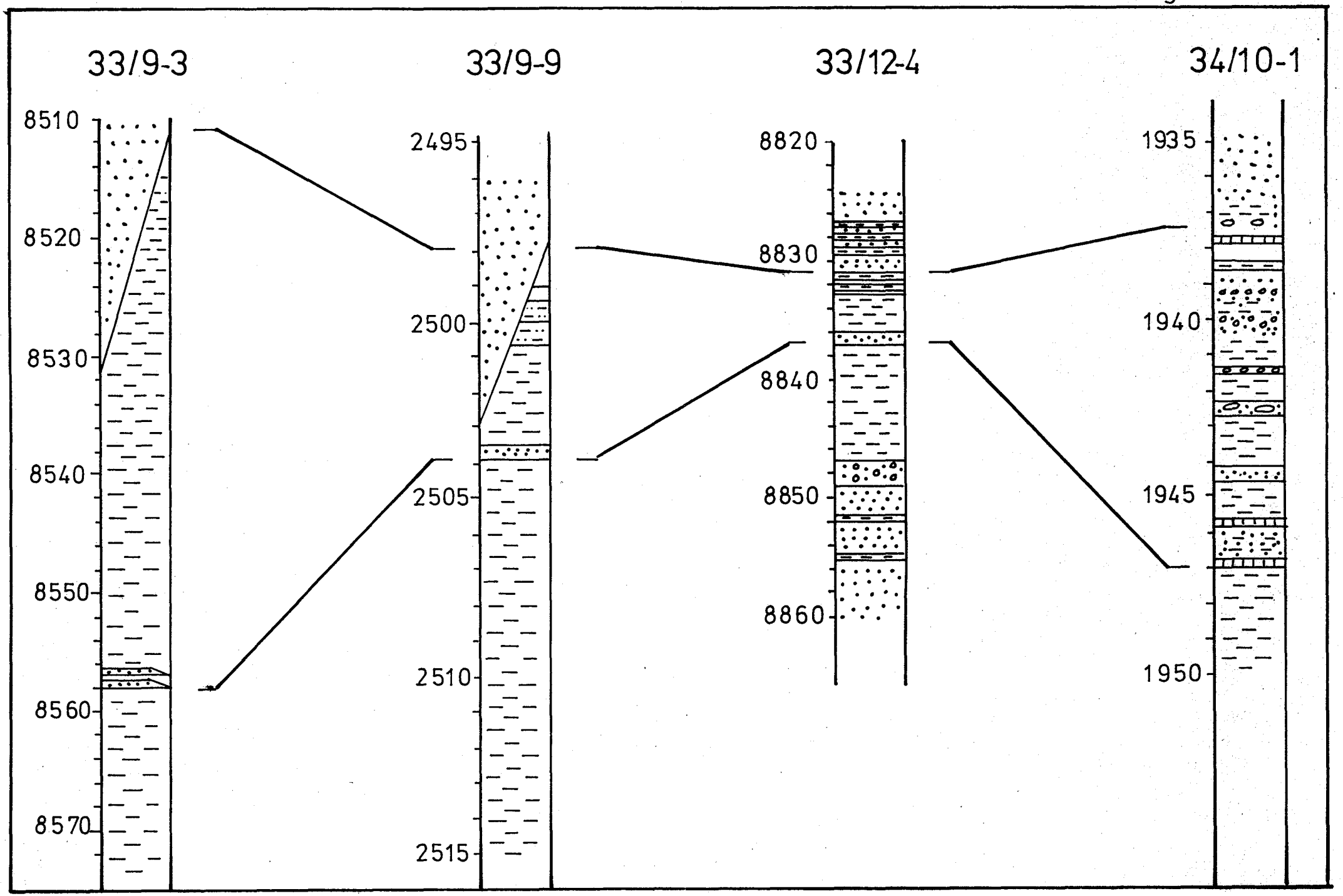
8 4 3 2 1 0 -1 -2 -3 -4 φ

FDD I W M DEGR S+P DINOS

3015
3020
3025
3030

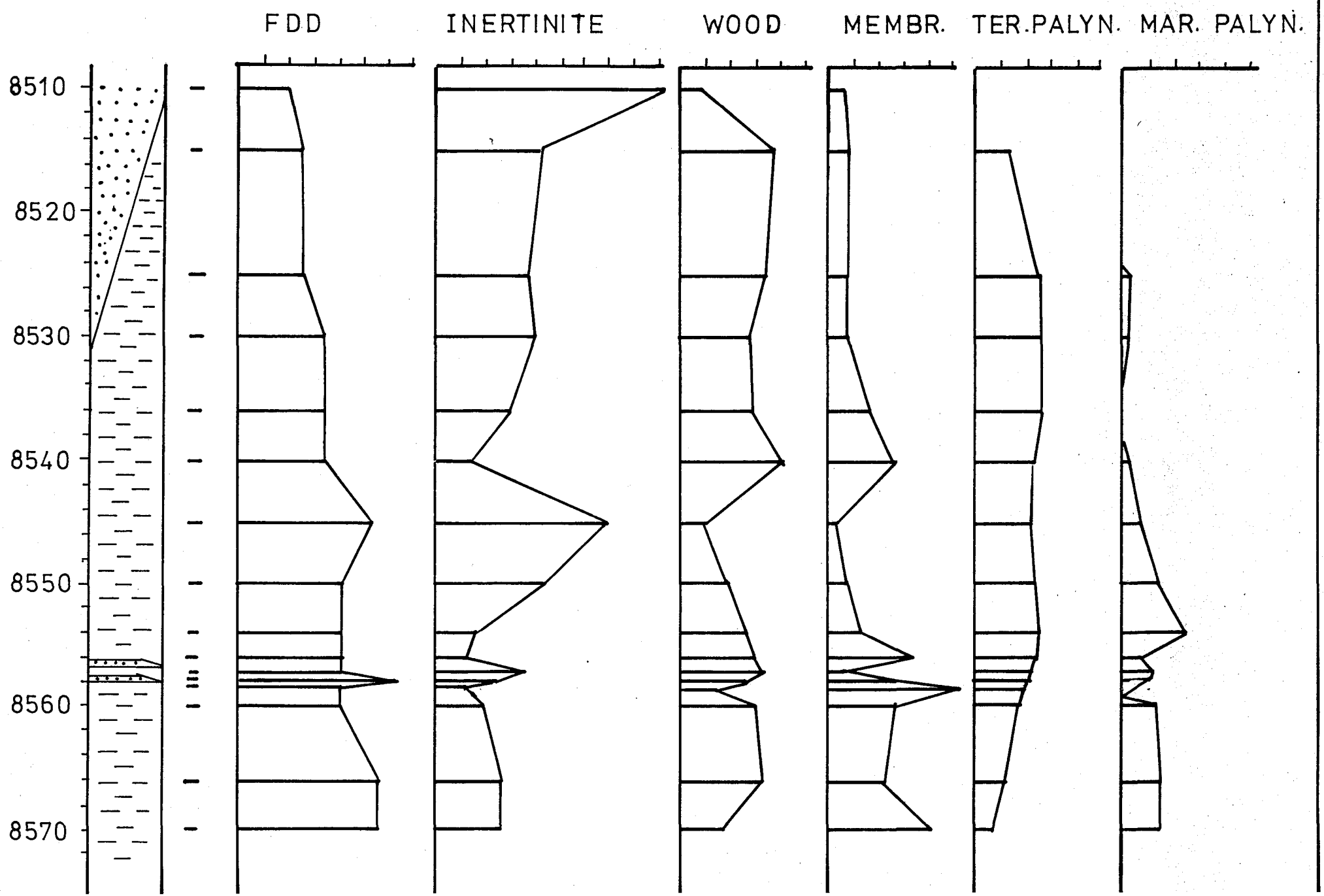
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203

Figure 1


33/9-3
33/9-9
33/12-4
34/10-1
8510
8520
8530
8540
8550
8560
8570
2495
2500
2505
2510
2515
8820
8830
8840
8850
8860
1935
1940
1945
1950

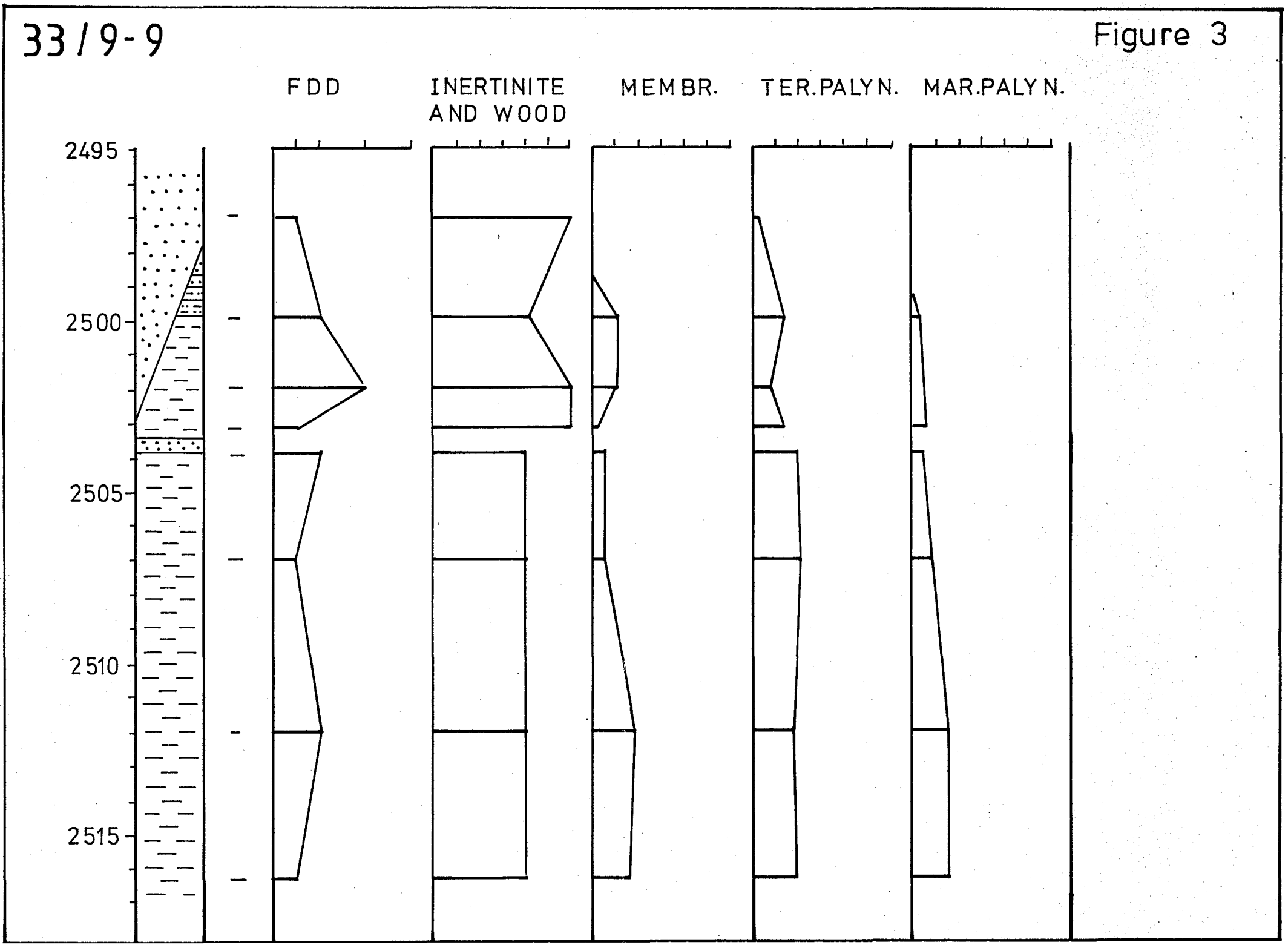
33/9-3

Figure 2



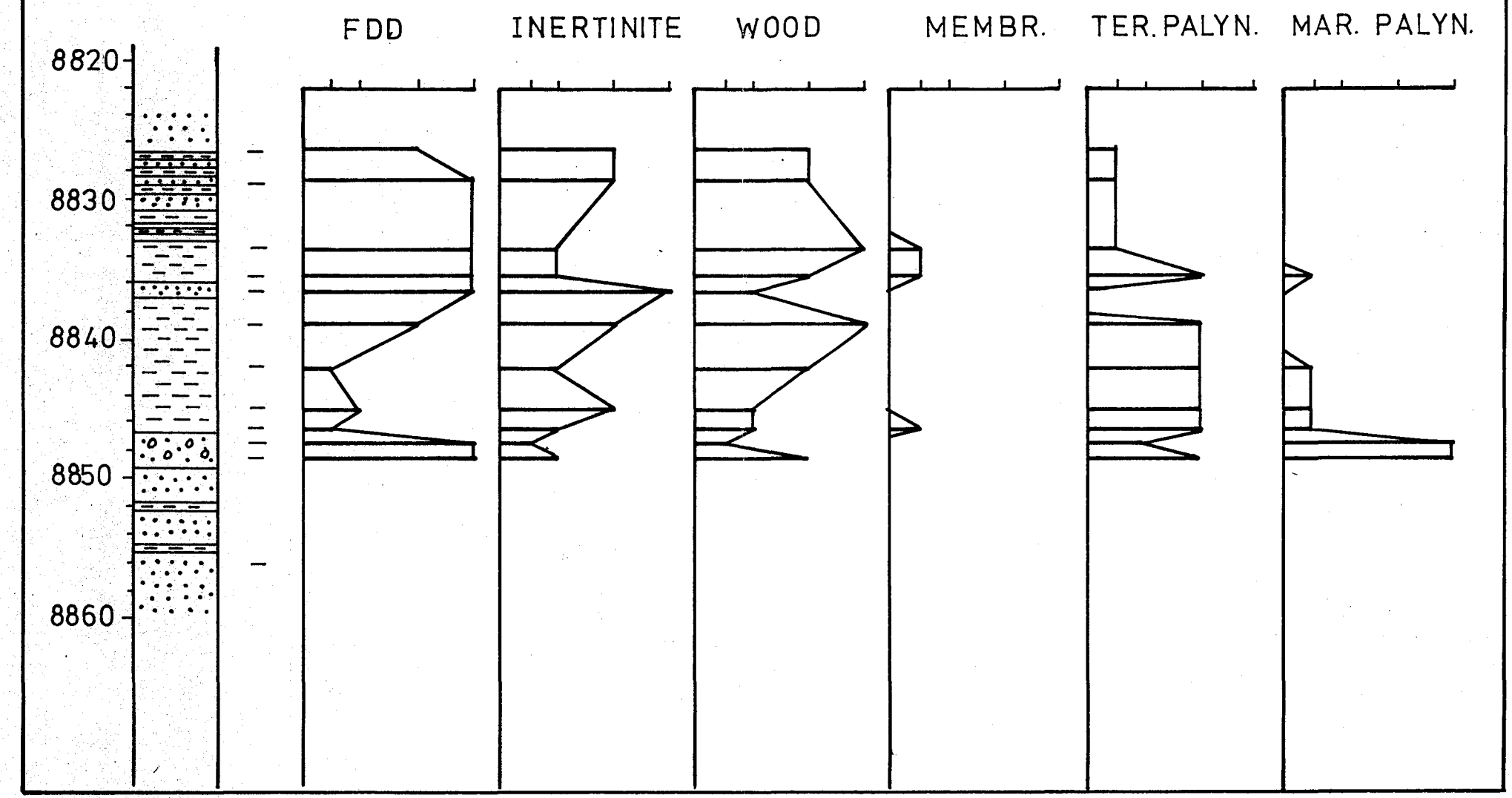
33/9-9

Figure 3



33/12-4

Figure 4



34/10-1

Figure 5

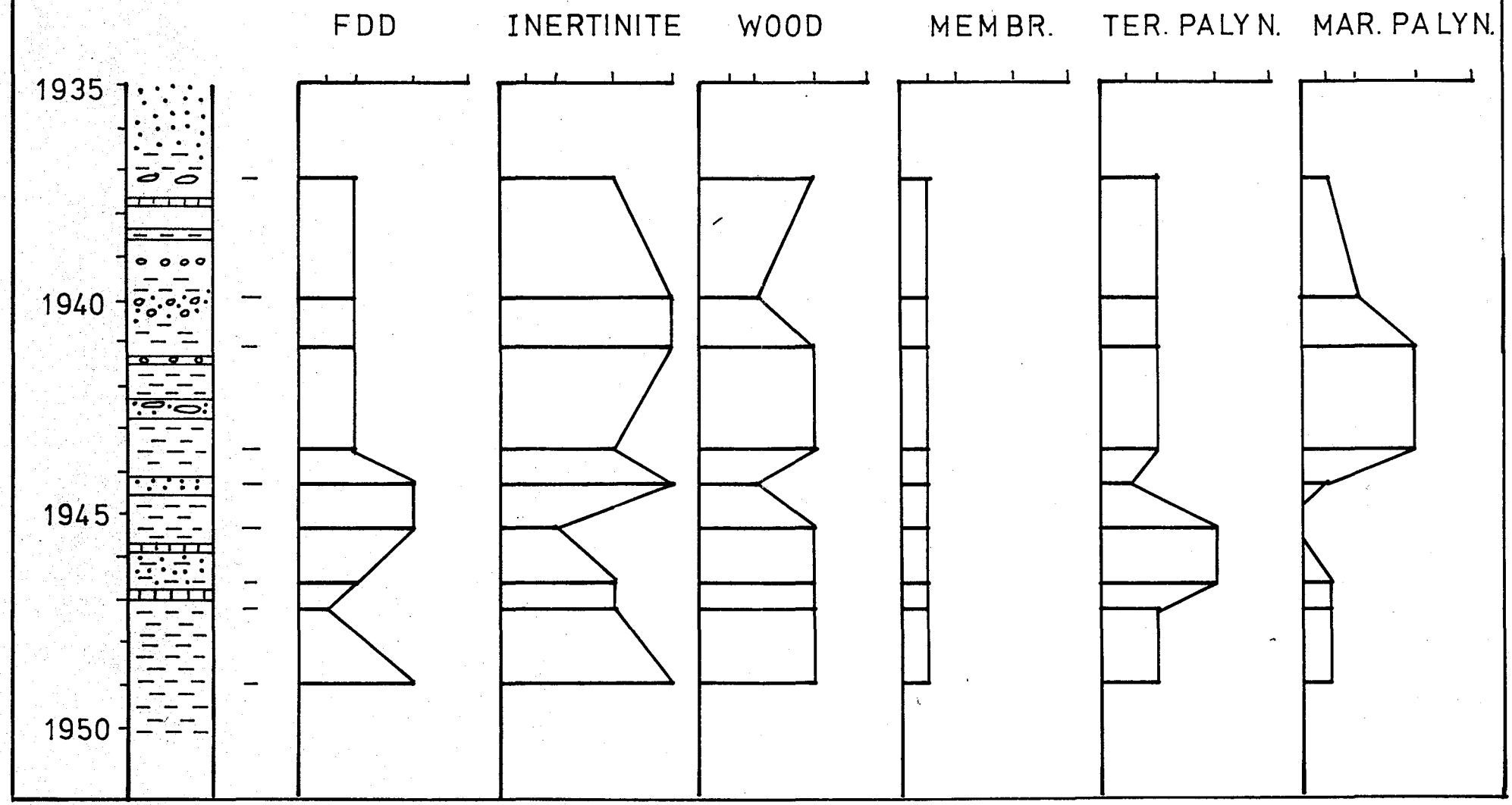
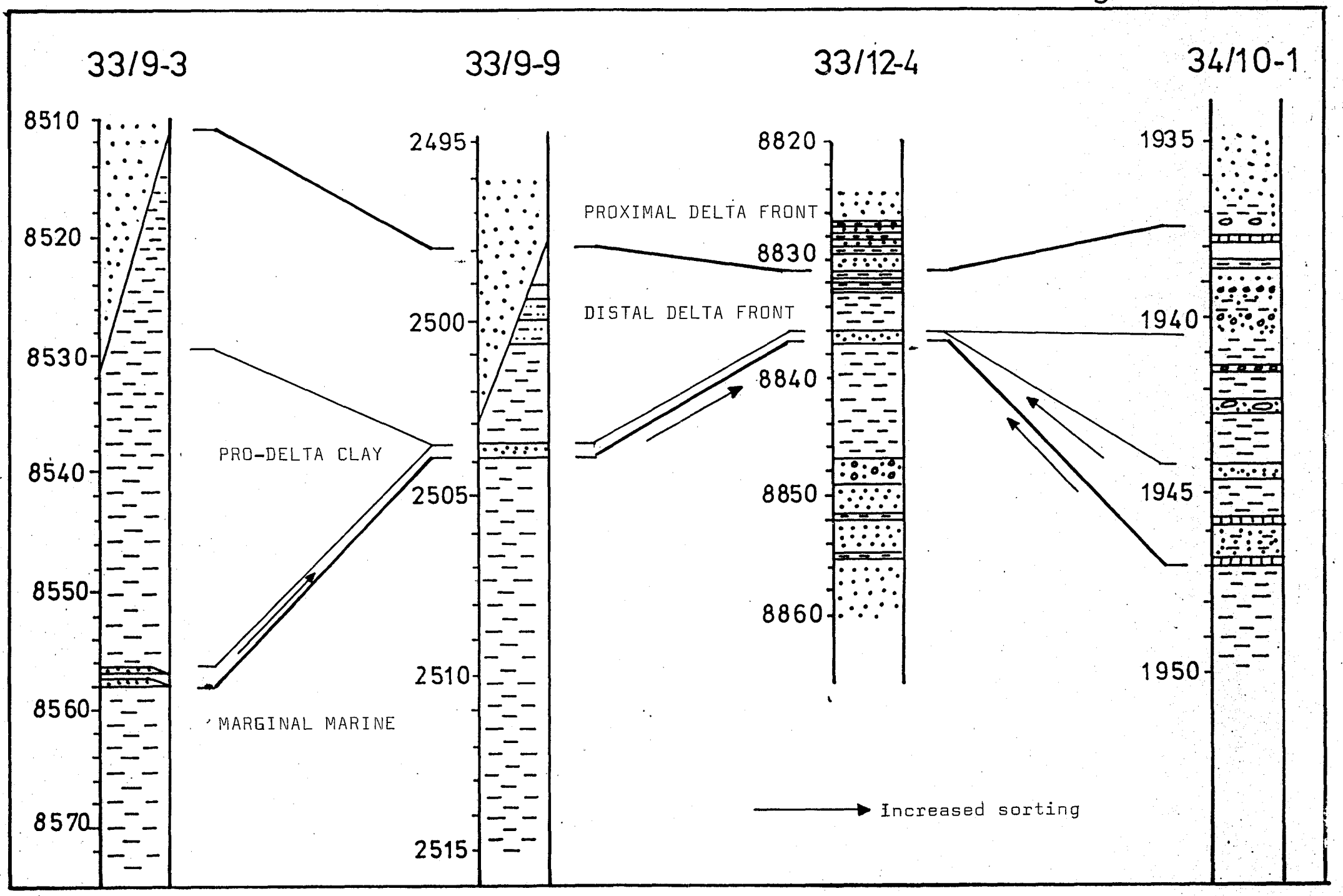


Figure 6


33/9-3
33/9-9
33/12-4
34/10-1
8510
8520
8530
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8560
8570
2495
2500
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2515
8820
8830
8840
8850
8860
1935
1940
1945
1950
PROXIMAL DELTA FRONT
DISTAL DELTA FRONT
PRO-DELTA CLAY
MARGINAL MARINE
Increased sorting