

Report EP-53465

Palynofacies investigation
in the Jurassic interval of the
Norsk Shell well 31/2-3

by
M.F. Whitaker
SIPM - EP/12
April 1981



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EXPLORATION AND PRODUCTION

EP-53465

PALYNOFACIES INVESTIGATION IN THE
JURASSIC INTERVAL OF THE NORSKE
SHELL WELL 31/2-3

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SUMMARY

A palynofacies analysis of the Jurassic strata from the Norske Shell well 31/2-3, was undertaken to assist in the interpretation of the depositional environments. A number of palynofacies types were identified, and according to their distribution, the following environmental picture is suggested :

After a period of relatively stable offshore lower, marine conditions, established during Toarcian times, the remaining Jurassic time appears to be characterized by strata deposited in a nearshore/coastal setting. The area emerged, possibly forming part of a coastal plain during Aalenian/Bajocian and Oxfordian/Kimmeridgian times.

The environmental sequence suggested for 31/2-3 is comparable in many of the intervals to the environmental setting observed for the wells 31/2-1 and 31/2-2.

KEY WORDS

31/2-3, 31/2-1, 31/2-2, 31/4-2, palynofacies, Norway, North Sea, offshore, environments, Jurassic, deltaic, dinoflagellates, sporomorphs, microplankton, palyno-debris.

1. INTRODUCTION

A palynofacies analysis of the Norske Shell well 31/2-3 (Norway) was undertaken in order to further the understanding of the environmental setting in which the Jurassic sediments of this area were deposited (see fig. 1). The study follows closely the analysis procedures established for the wells 31/2-1 and 31/2-2 (report EP-53031). The latter report also includes a description and discussion of the palynological constituents and palynofacies types, together with their environmental significance. As a reference and guide, illustrations from report EP-53031, summarizing the distribution of the various palynofacies types in on-delta and offshore environments, are included (figs. 3-5).

Palynofacies studies were confined to core and sidewall core material which was prepared using a standard procedure. Tables presenting a semi-quantitative distribution of the constituents, together with a summarized environmental interpretation are given (Tables 1-4).

Sixteen sequences of palynofacies types have been recognized. The environmental significance of these sequences are discussed in the following section, in stratigraphical order and illustrated together with results from 31/2-1, 31/2-2 and 31/-4-2 in fig. 2 and encl. 1.

2. RESULTS

The palynofacies study in the Jurassic interval from the Norske Shell well 31/2-3 included the analysis of 78 core and sidewall core samples. From the distribution of the palynological constituents a number of palynofacies types could be identified, which could further be grouped into the following 16 palynofacies sequences.

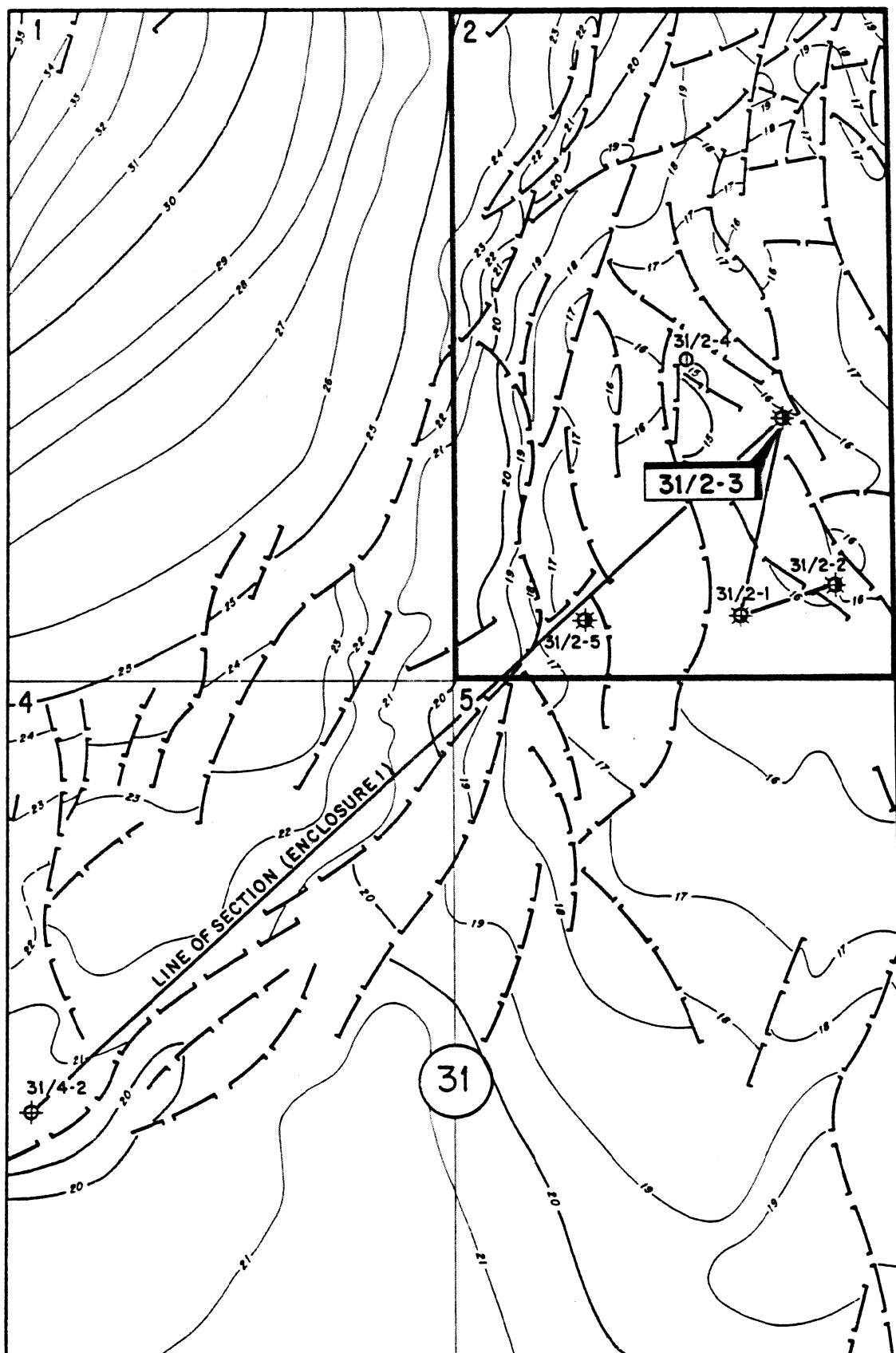


FIGURE 1

GENERAL LOCATION MAP
(Base Cretaceous play map 1:250 000)

Sequence 1

Interval : 1978.0 - 1874.0 m

Age : Toarcian-?Aalenian/?Bajocian

Description

Palynofacies are generally characterized by a high proportion of sporomorphs and bisaccates, a significant dinoflagellate cyst content, and a low proportion of less buoyant small dense woody debris. Palynofacies types include IV, VI, and at the base of the sequence a palynofacies type containing features common to both II and V. The latter association includes ?structureless organic matter which in this particular case might be of plant origin.

Discussion

The lowest palynofacies type of this sequence, i.e. V/II, indicates at this time the presence of anaerobic bottom conditions, and proximity to a terrestrial source of organic material. The occurrence of palynofacies type IV at 1933.0 and 1903.0 m indicates a low energy, distal, possibly shallow, offshore lower, marine environment. The increase of opaque material at 1874.0 m may suggest a higher energy, possibly shallower marine setting. (See also discussion sequence 3).

Sequence 2

Interval : 1867.0 - 1815.5 m

Age : ?Aalenian/?Bajocian

Description

Palynofacies are generally characterized by a high proportion of opaque and sometimes small degraded woody material. Microplankton was not observed. A palynofacies obtained from the coal SWS (1867.0 m) consisted predominantly of blade opaque material.

Discussion

The absence of microplankton, together with the degraded, often rounded appearance of the constituents, indicate a high energy, shallow water environment for much of this interval. The general increase of the rounded constituents in the upper part of the sequence suggest an environment of a littoral nature, such as associated with a beach-shoreface or channel setting.

Sequence 3

Interval : 1806.5 - 1772.0 m

Age : Bathonian (Middle)

Description

Palynofacies are in general characterized by a high proportion of small and occasionally large woody and epidermal plant debris. Much of this plant material is highly degraded. In the palynodebris of the lower two palynofacies from this sequence, a low proportion of small opaque material is present. A low proportion of ?structureless organic matter also characterizes these palynofacies, most of which may have originated from severely degraded plant debris (?bacterial degradation). Sporomorphs and bisaccates are generally well represented. In the palynodebris from the uppermost palynofacies of this sequence, however, bisaccates are absent. Dinoflagellate cysts are well represented and increase in density towards the lower part of this sequence.

Discussion

The progradation of a shoreline, from a marine offshore upper to shoreface environment is suggested by this sequence of palynofacies types. At the base of the sequence, at 1796.0 and 1806.5 m, palynofacies are intermediate to types V and II. The microplankton content is sufficiently diverse and well represented, together with a high bisaccate proportion to indicate a marine, probably offshore upper environment. The proportion of plant debris and its severely degraded, almost structureless nature, suggests proximity to a supply of terrestrial organic debris. Abundance of terrestrial organic debris may have promoted high bacterial activity, so reducing the oxygen content and consequently creating anaerobic bottom conditions. The subsequent lowering of bacterial activity results in the preservation of partially degraded plant material (?structureless organic material), normally "cleaned up" in more oxic environments. Such conditions are also enhanced by an irregular sea bottom topography, perhaps associated with fault activity of the time.

Towards the top of this sequence, there is a general reduction of dinoflagellate diversity and frequency. In palynodebris from the uppermost palynofacies, a virtual absence of bisaccate pollen, together with an increase in the less buoyant woody plant debris and a lower dinoflagellate cyst content, may suggest an increase in the energy of the environment, possibly indicating a shoreface setting.

Sequence 4

Interval : 1760.0 - 1757.0 m

Age : Bathonian (Middle)

Description

The lower palynofacies (XIII) of this sequence is characterized by a high proportion of sporomorphs, a low proportion of bisaccate pollen, and a poor dinoflagellate cyst content. Plant debris consists mainly of small woody and epidermal material. The upper palynofacies from this sequence is characterized by a high proportion of large and small dense woody plant debris, and a low sporomorph and dinoflagellate cyst proportion. Bisaccates are virtually absent.

Discussion

This sequence may possibly represent a more lateral shift from an "embayment" to a shoreface environment. The high proportion of sporomorphs, but virtual absence of bisaccates, suggests a low energy, depositional setting, close to vegetation, but away from a fluvial influence, carrying bisaccate pollen from the hinterland. The poor dinoflagellate content also indicates unfavourable salinities or energy. These features are perhaps most consistent with a protected, semi-enclosed coastal setting or embayment.

The reduction of the relatively buoyant sporomorph proportion, and the concentration of less buoyant dense woody material in the upper palynofacies of this sequence suggests high energy, winnowing conditions, possibly associated with a shoreface environment.

Sequence 5

Interval : 1749.0 - 1695.0 m

Age : Bathonian (Middle)-Bathonian (Late)/Callovian (Early)

Description

Palynofacies are generally characterized by high proportions of small and sometimes large dense woody, woody and to a lesser extent epidermal material. Dinoflagellate cysts are often well represented, although they are absent at 1728.0 m, and notably reduced at 1732.9 m. Sporomorphs occurring in significant proportions characterize the lower palynofacies from this sequence, and are progressively reduced in proportion in the upper samples. Bisaccate pollen are present only in the lowest palynofacies from this sequence. Opaque material also characterizes in low proportions the palynofacies from the lower part of the sequence.

Discussion

This sequence is considered to involve a shift of environment from a lower to a higher shoreface environment and perhaps representing in its upper part a marine incursion. The association of a moderate sporomorph proportion, a relatively buoyant constituent, together with a moderate dinoflagellate cyst content and significant proportion of the less buoyant dense woody material, in the lower palynofacies of this sequence, may indicate an environmental setting transitional to offshore upper and shoreface. In such an environment, energy conditions at the sea bottom are low enough to allow the setting out of more buoyant constituents, salinity high enough for dinoflagellate life, but storm processes are still effective in introducing the less buoyant constituents.

The further increase of small dense woody material in palynodebris of the upper palynofacies from this sequence, together with the virtual absence of the more buoyant constituents (i.e. sporomorphs), indicates a high energy environment comparable to upper shoreface. The relatively high dinoflagellate cyst diversity and moderate frequency which characterize the uppermost palynofacies may suggest this part of the sequence to be representative of a high energy, marine environment, and perhaps associated with a marine incursion.

Sequence 6

Interval : 1681.5 - 1661.0 m

Age : Callovian

Description

The lowest palynofacies type V of this sequence is characterized by a high proportion of dinoflagellates together with a low/moderate proportion of woody, dense woody, and epidermal plant debris, sporomorphs, bisaccate pollen and opaque material. The two upper palynofacies types VIII of this sequence are characterized by an increase in the proportion of small dense woody material, and a decrease in the proportion of sporomorphs, bisaccate pollen and dinoflagellate cysts. A low proportion of large blade opaque material is present at 1668.5 m.

Discussion

This sequence of palynofacies is comparable to those described in the previous sequence 5, and most likely represents a brief interval of a marine offshore upper environment at its base, including perhaps a marine incursion in the uppermost part of the sequence 5. This is followed by a return to an upper shoreface or coastal channel setting (see discussion of sequence 5).

Sequence 7

Interval : 1644.2 - 1631.8 m

Age : Callovian

Description

The palynofacies observed from the lower part of this sequence are intermediate in type to VI and VII. They are characterized by a low dinoflagellate proportion and diversity, low sporomorph and bisaccate proportions, and a high proportion of large and small woody and dense woody plant debris. Palynofacies VB/XIIIB encountered above, are characterized by only a single dinoflagellate cyst, small plant debris, a high proportion of sporomorphs, but only rare bisaccates, all of which are poorly preserved. In the palynodebris from the upper part of this sequence dinoflagellate cysts were not observed, sporomorphs and bisaccates are rare. It is, furthermore, characterized by large and small, frequently rounded plant debris together with blade opaque material.

Discussion

The lower palynofacies indicate a clear marine influence and moderate to high energy conditions since the more buoyant constituents (sporomorphs, bisaccates, epidermal SPM) appear to have been winnowed out. A marine lower shoreface environment thus seems likely. The virtual absence of dinoflagellate cysts and bisaccate pollen, but high proportion of sporomorphs which characterize the palynofacies above, suggest a depositional low energy environment, close to shore, perhaps an "embayment"*. The palynofacies from the uppermost part of this sequence indicates a high energy upper shoreface environment or possibly a coastal/fluviial channel.

*"Embayment" is used here to describe a relatively enclosed depositional shoreface environment, intermediate in character to shoreface and lagoon.

Sequence 8

Interval : 1621.0 - 1607.5 m

Age : Callovian

Description

The lower two palynofacies from this sequence are characterized by a low diversity and frequency of dinoflagellate cysts, a significant proportion of sporomorphs, woody and dense woody plant debris, together with a small proportion of large epidermal plant material. Bisaccates occur rarely. The upper palynofacies is characterized by an increased proportion of large dense woody material and low sporomorph proportion. Dinoflagellate cysts were not observed, but a low proportion of small palynomorphs occur, possibly leiospheres or disassociated microforam chambers.

Discussion

The above palynofacies sequence appears to indicate a change from a marine, possibly semi-enclosed setting (suggested by the presence of ?leiospheres and high sporomorph proportion), to a shoreface environment. The rarity of bisaccate pollen in such a depositional environment may indicate little direct fluvial influence (see discussion of sequence 4) in the lower part of this sequence. The concentration of the less buoyant constituents in the upper part of this sequence suggests a distinct increase in energy in a coastal setting, possibly a shoreface.

Sequence 9

Interval : 1590.3 - 1583.5 m

Age : Callovian

Description

All palynofacies are characterized by small and large woody and epidermal plant material. The two lower palynofacies XIII^B/V^B of this sequence consist of a moderate proportion of sporomorphs together with a small proportion of bisaccates. These proportions are significantly reduced in the palynodebris from the higher part of this sequence. A low diversity and frequency of dinoflagellates occur at the base of the sequence.

Discussion

The above sequence of palynofacies very probably indicate a lateral shift of environment, parallel to the coastal/delta margin. In the lower part, the high proportion of sporomorphs relative to bisaccate pollen, suggests a depositional environment with little direct fluvial influence (see discussion sequence 4), and together with a low dinoflagellate cyst content, an "embayment" like setting seems likely. In the upper part, the palynofacies suggest an environment which is of a more dynamic nature, where the more buoyant constituents are maintained in suspension. The absence also of dinoflagellate cysts suggests a strong fresh water influence. These latter two features appear most consistent with an environment proximal to a river mouth.

Sequence 10

Interval : 1578.9 - 1573.07 m

Age : Callovian

Description

Both palynofacies consist of a low proportion and diversity of dinoflagellate cysts. The palynofacies type V^B/XI^B, from the lowermost part of this sequence, is also characterized by a low proportion of bisaccate pollen and sporomorphs, together with large and small woody, dense woody, and epidermal plant debris. The palynofacies type VII, from the uppermost part of this sequence, is characterized by mainly woody and dense woody debris, with only a few sporomorphs.

Discussion

The palynofacies most likely reflect a change from an innermost shelf/river mouth area in the lower part of the sequence, to a high energy shoreface environment in the upper part.

Sequence 11

Interval : 1561.7 - 1521.7 m

Age : Callovian

Description

All palynofacies are characterized by high proportions of large and small woody and epidermal plant debris. Sporomorph and bisaccate pollen proportions are generally low. Dense woody material (large and small particles) increases in two palynofacies (XI/? XIII and XI) at 1521.7 and 1532.2 m. Dinoflagellate cysts are rare, except in the lowest palynofacies V/XI^B in which cysts of a low proportion and diversity are present. The uppermost palynofacies type XI^{BR} is barren of dinoflagellates and the plant debris is partly rounded.

Discussion

The lowermost part of this sequence shows marine influences comparable to those observed in the basal part of sequence 3 (offshore upper/river mouth). The generally low sporomorph and bisaccate pollen proportions, and rare dinoflagellate cysts occurrence indicate a more dynamic higher energy environment towards the upper part, probably ending in a shoreface setting at the top.

Sequence 12

Interval : 1514.5 - 1496.3 m

Age : Callovian (?Oxfordian)

Description

All palynofacies are characterized by large and small woody, epidermal and to a lesser extent dense woody plant debris. Dinoflagellate cysts are generally well represented, and where they occur abundantly (e.g. at 1500.4 m palynofacies X), one morphological type, Chytroeisphaeridia spp., dominates. Leiospheres and animal tissue are also present. Sporomorph and bisaccate pollen proportions are generally low, although they are high in palynofacies X at 1500.4 m. The palynofacies VII/VI at 1506.7 m is characterized by large and small dense woody debris.

Discussion

The sequence is predominantly marine. However, the predominance of one morphologically simple type, together with ?leiospheres and animal tissue strongly suggests brackish influence. These environmental conditions might have prevailed near a river mouth ("embayment"). The palynofacies at 1506.7 m suggests a high energy shoreface environment.

Sequence 13

Interval : 1491.65 - 1465.3

Age : Oxfordian (Early)

Description

Many of the palynofacies are characterized by a low proportion of plant debris, a high proportion of bisaccate pollen, sporomorphs, and small opaque material, together with a moderate to high dinoflagellate cyst proportion and diversity. Palynofacies VIII/VII and VI from a short interval between 1476.8 and 1478.6 m, and to some extent at 1487.3 m, are characterized by a higher proportion of dense woody material and a lower sporomorph and bisaccate pollen proportion.

Discussion

Palynofacies indicate a marine upper offshore environment for much of this interval. The occurrence of a significant proportion of Chytroeisphaeridia and Tenua spp. in the lower part of this sequence suggests a coastal influence. The palynofacies of the interval 1476.8 - 1478.6 m, may reflect a higher energy upper shoreface or channel environment.

Sequence 14

Interval : 1459.3 - 1447.9 m

Age : Oxfordian (?Early)

Description

At 1447.9 and 1459.3 m palynofacies IX consists only of small angular opaque material. The palynodebris at 1453.0 m consists almost entirely of Tertiary material, which is probably due to mud contamination.

Discussion

The above palynofacies indicate a high energy environment possibly at times exposed to subaerial processes.

Sequence 15

Interval : 1434.9 - 1408.3 m

Age : Oxfordian (Late/Early)

Description

The lower two palynofacies V/VI are characterized by a moderate/good dinoflagellate cyst diversity, a high proportion of bisaccate pollen and sporomorphs, and blade opaque material. In the remaining palynofacies VII and IX^S, dinoflagellates are absent, although the uppermost palynofacies VII contains a few ?leiospheres or broken microforams. Sporomorph and bisaccate pollen are also rare or absent. Large and small blade opaque material characterize two of these palynofacies at 1417.38 and 1427.8 m. Between, at 1426.0 m, occurs palynofacies IX^S consisting of only tiny/small woody and opaque material.

Discussion

The sequence of palynofacies most likely reflects a gradual change from a marine, offshore upper / lowermost shoreface environment, to a high energy, beach-like setting.

Sequence 16

Interval : 1406.0 - 1384.5 m

Age : Late Oxfordian-Kimmeridgian

Description

The lower palynofacies of this sequence, types V and VI, are characterized by moderate diversities and a low frequency of dinoflagellate cysts, a high proportion of small opaque material and a generally low sporomorph and bisaccate pollen proportion. The lowest palynofacies V consists of a low/moderate proportion of woody, dense woody and epidermal plant debris, together with a proportion of large blade opaque material.

Palynofacies higher in the sequence are more variable in their proportion of plant debris types. In the middle part of the sequence, at 1388.0 and 1402.3 m, a higher proportion of dense woody material is present, which in the latter sample is of a relatively large size. The palynofacies at 1402.3 m is also characterized by the absence of sporomorphs, bisaccates and epidermal plant material.

The upper two palynofacies from this sequence are characterized by the predominance of mainly small woody material. Dinoflagellates are absent.

Discussion

This sequence of palynofacies is comparable to those of sequences 5 and 15, and most likely represents a gradual change from a marine offshore upper/lowermost shoreface environment (see discussion of sequence 5), via a shoreface setting, to a very high energy, beach like setting.

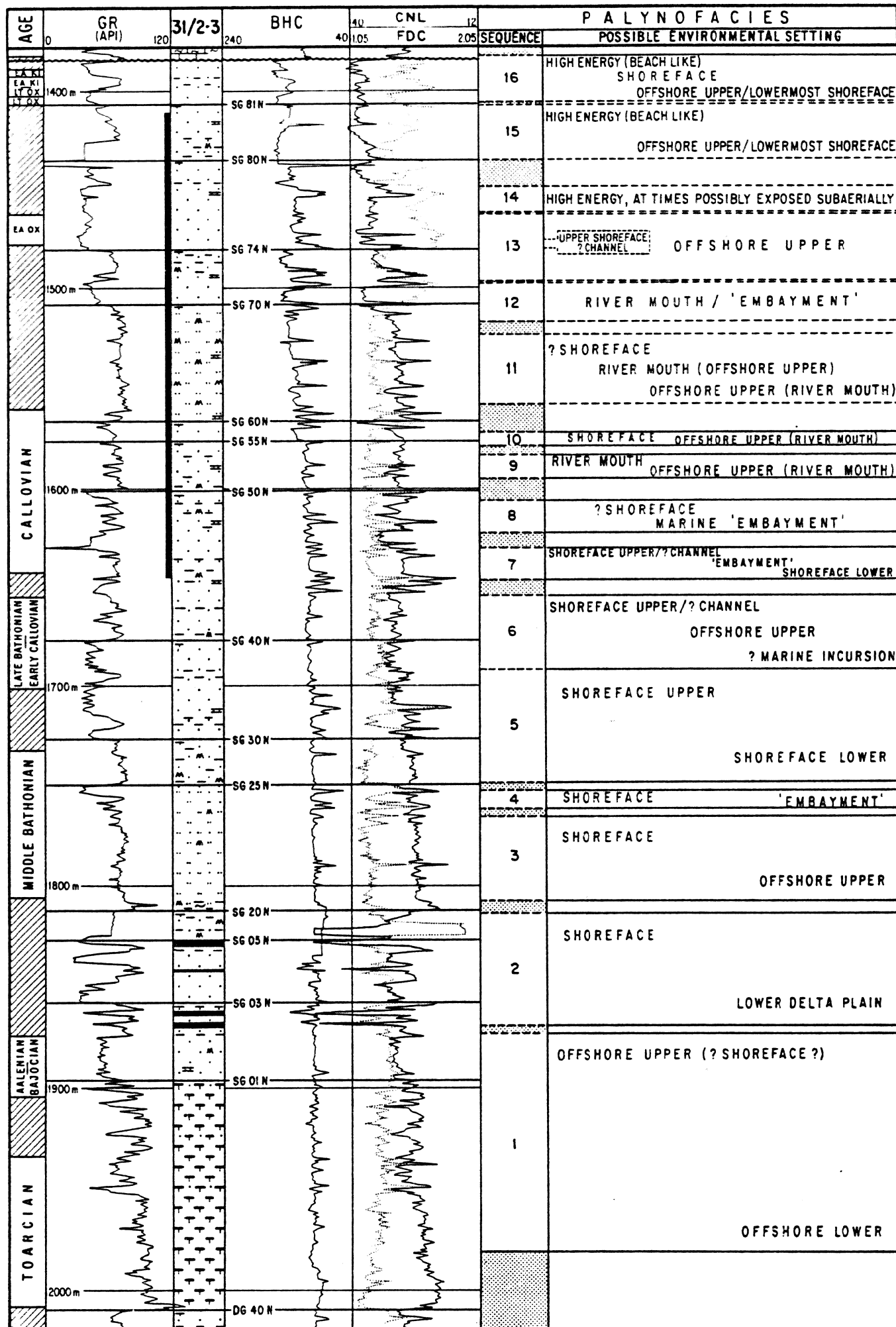


FIGURE 2

PALYNOFACIES SEQUENCES AND THEIR SUMMARIZED ENVIRONMENTAL INTERPRETATION IN 31/2-3

3. CONCLUSIONS

By applying principles described in report EP-53031, the following general environmental interpretation of the Jurassic interval from the Norske Shell 31/2-3 is suggested.

A predominantly nearshore/coastal environment is indicated for most of the Jurassic interval studied, with the exception that the lowest sediments from sequence 1 (Dunlin Equivalent) are of a more marine aspect. The area was emergent, possibly forming part of a coastal plain during the Aalenian/Bajocian interval (sequence 2) and in Oxfordian/Kimmeridgian times (sequences 14 and 15).

Many of the palynofacies sequences recognized are regressive, beginning in many examples in a marine influenced or offshore setting, becoming in the upper part more coastal in character. In some cases a sequence, or part of a sequence, more likely represents a lateral shift from a low to higher energy coastal environment (see fig. 2).

The Toarcian interval (sequence 1) begins with palynofacies of a marine offshore lower environment, becoming in the upper part of this interval more indicative of a higher energy, possibly more shallow marine setting, perhaps lateral to the central deltaic area.

The overlying Aalenian/Bajocian interval (sequence 2) contains palynofacies indicating high energy conditions comparable to beach, shoreface or channel settings, and possibly forming part of a coastal plain complex.

The Bathonian/Early Callovian (sequences 3-10) continues with palynofacies indicating a predominantly shoreface setting.

The Callovian interval continues, at the base of sequence 11, with palynofacies suggesting a marine offshore lower environment, which in the middle part of this interval is more fluvial dominated, and then in the following sequence 12, prior to the Oxfordian interval, possibly estuarine together with shallow marine embayments represented.

Sequence 13 from the lower part of the Early Oxfordian interval, appears to be predominantly of an offshore upper environment. The overlying more sandy interval may represent the base of a coastal channel, returning to a more marine offshore environment in its upper part.

The remaining Oxfordian and Kimmeridgian intervals contain palynofacies which indicate essentially two prograding units beginning in a marine offshore setting becoming higher energy and beach like and possibly even subaerial, in their upper part (sequences 14-16).

The palynofacies described from the adjacent wells 31/2-1 and 31/2-2 to the south indicate in general a similar nearshore/coastal setting for the Middle and Upper Jurassic (lower part) interval. Palynofacies from the Toarcian-Early Oxfordian (lower part) interval compare especially with those from the same interval in 31/2-2. The higher energy palynofacies of the Late Oxfordian and Kimmeridgian intervals are possibly more comparable to the semi-emergent setting suggested for the Kimmeridgian of 31/2-1.

Palynofacies have also been described from part of the Jurassic sequence of Hydro 31/4-2 (EP-53464), a well which is situated in the most westerly part of the Norwegian "Flat Head" area (see fig. 1). Much of the sequence (Toarcian-Callovian interval) appears to represent a relatively more offshore situation. The Late Callovian/Early Callovian interval, however, contains palynofacies indicating a shallow water shoreface marine environment.

To summarize, 31/2-3 together with 31/2-1 and -2 appear to have been situated for much of the Jurassic period in a coastal/marginal deltaic setting, a fully offshore marine environment being established only in the Early and Latest Jurassic intervals. Offshore conditions are more generally established to the west in the area of 31/2-4, particularly during Toarcian, Bajocian (?Late)-Callovian (?Middle) times, (see Enclosure 1).

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the Norske Shell wells 31/2-1 and 31/2-2.

EP-53031, February 1981

WHITAKER, M.F., 1981

A palynofacies investigation in the Jurassic interval of
the Norsk Hydro well 31/4-2.

EP-53464

TABLE 1

[illegible]

bwSPM = Dense woody structured plant material; WSPM = Woody structured plant material; ESM = Epidermal structured plant material; OM = Opaque and semi-opaque material; dwSPM = Dense woody structured plant material; ESM = Epidermal structured plant material; OM = Opaque and semi-opaque material;

SOM = Structureless organic matter; D% = Degradation; C% = Carbonisation; AV = Adjusted diversity; T = Total frequency; DP = Rounded

PV2 = Bisaccates; Tissue Type A = ?Animal tissue; S = Small; M = Medium; L = Large.

TABLE 2

[illegible]

TABLE 4

[illegible]

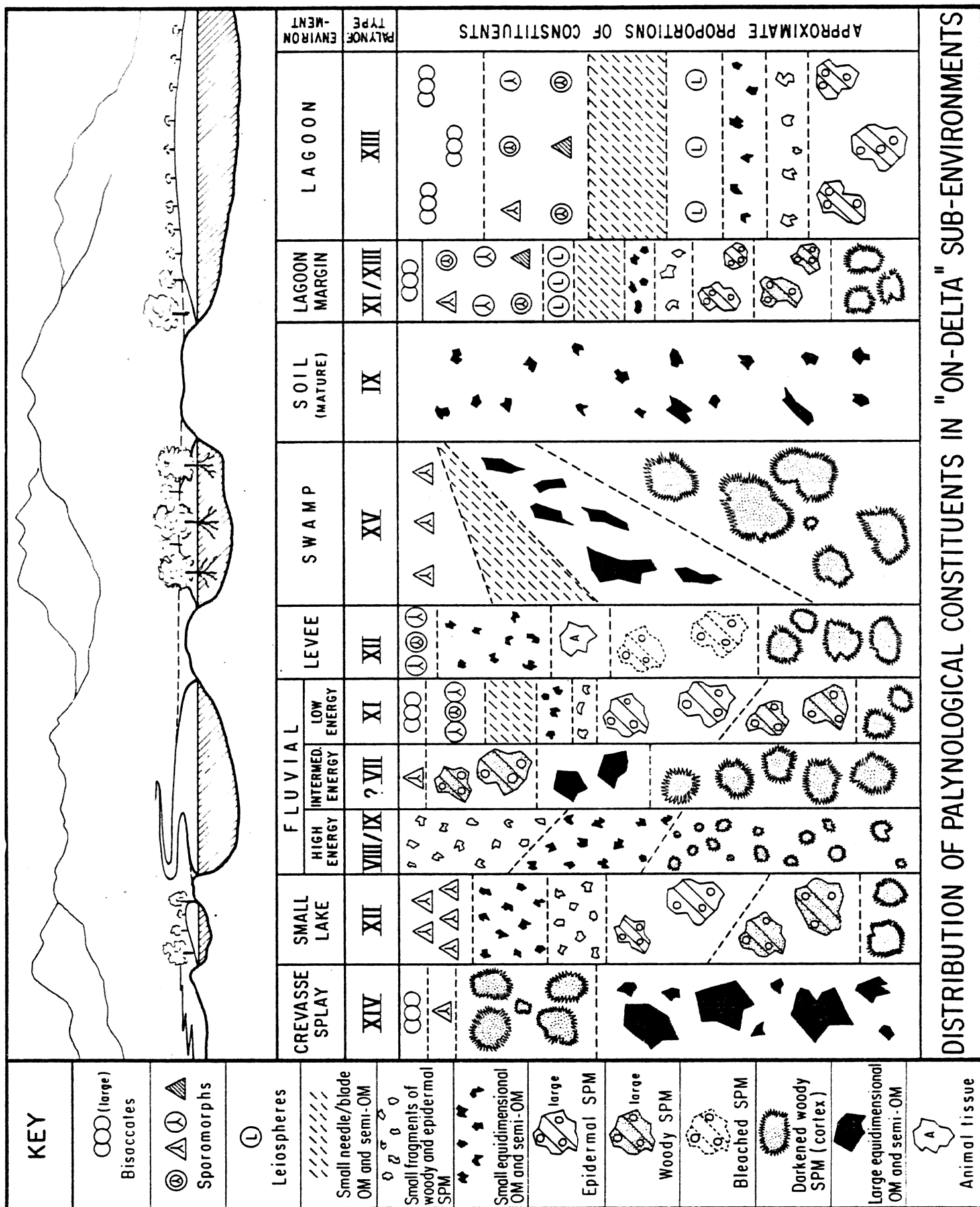
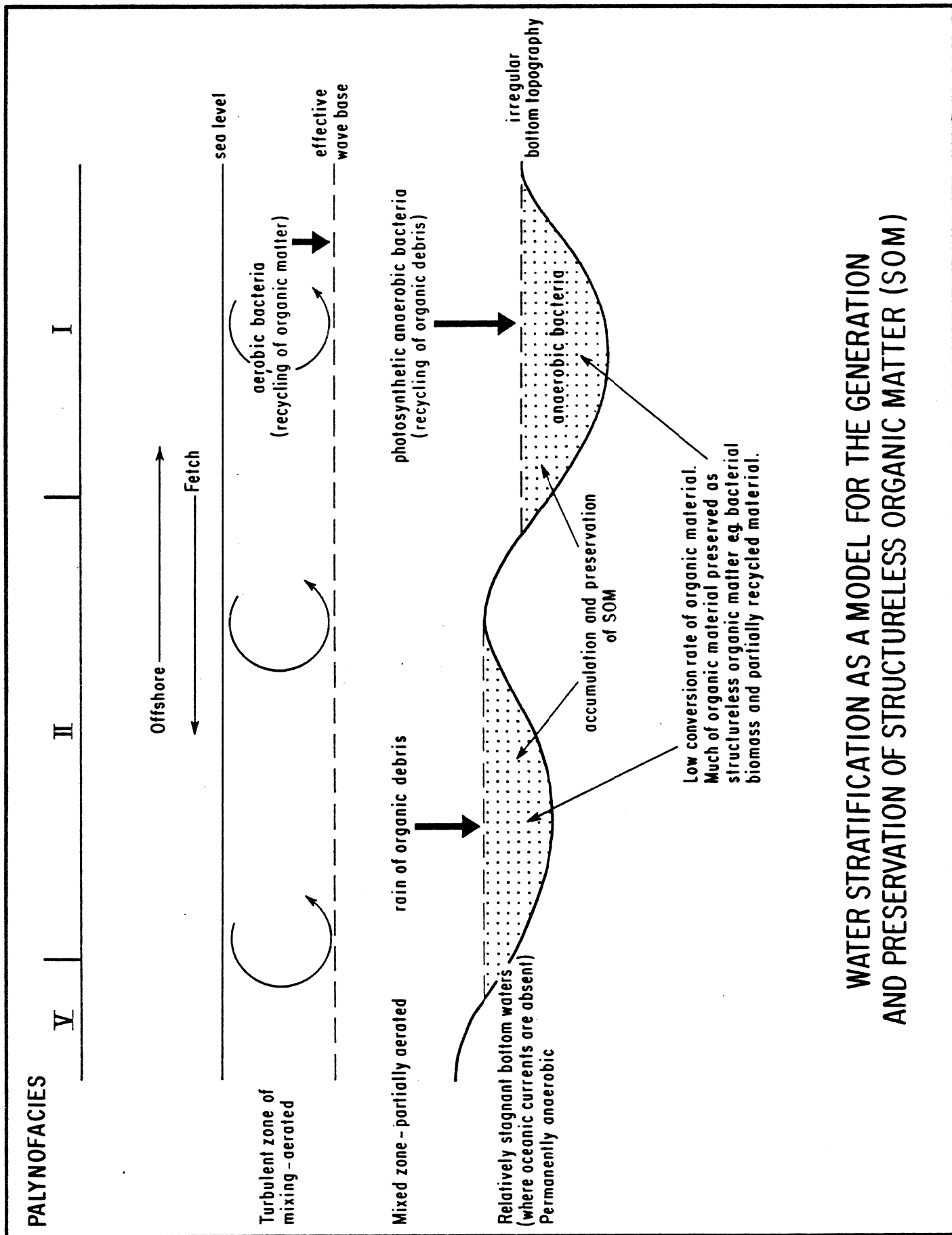
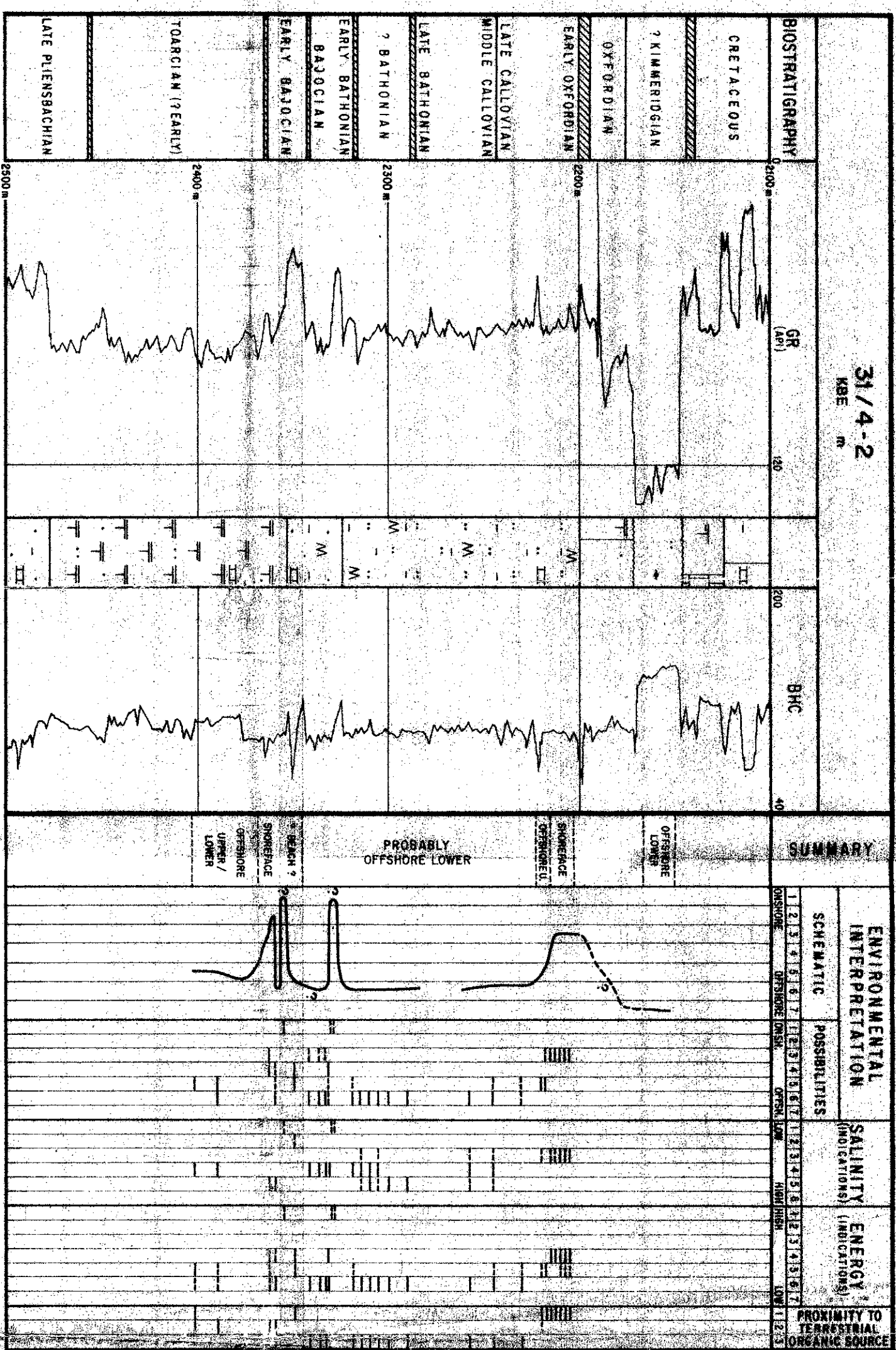


FIGURE 4



WATER STRATIFICATION AS A MODEL FOR THE GENERATION
AND PRESERVATION OF STRUCTURELESS ORGANIC MATTER (SOM)

FIGURE 5



KEY

SCHEMATIC & POSSIBILITIES

1. LOWER / UPPER DELTA PLAIN
2. BEACH / LITTORAL / CHANNEL
3. SHOREFACE / ESTUARINE / LAGOONAL
4. SHOREFACE LOWER
5. OFFSHORE UPPER - SHALLOW
6. OFFSHORE LOWER - SHALLOW
7. OFFSHORE LOWER - DEEP

SALINITY (INDICATIONS)

1. MICROPLANKTON ABSENT
2. LESOSPHERES ONLY
3. MICROPLANKTON MONOSPECIFIC
4. LOW DIVERSITY / SIMPLE MORPHOLOGY
5. MODERATE DIVERSITY
6. HIGH DIVERSITY / COMPLEX MORPHOL.
7. S.O.M.

ENERGY (INDICATIONS)

1. TINY / SMALL ORPACUE CONSTITUENTS
2. TINY / SMALL ORPACUE / WOODY CONSTITUENTS
3. ROUNDED / ROLLED CONSTITUENTS
4. LARGE ON / DWSPM
5. LARGE - SMALL WSPM / ESPM
6. SMALL ON / WSPM / ESPM + BI
7. S.O.M.

PROXIMITY (INDICATIONS)

1. LARGE CONSTITUENTS / GOOD PRESERVATION / MONOSPECIFIC SPORE ASSEMBLAGES
2. INTERMEDIATE
3. SMALL BUOYANT CONSTITUENTS / POOR PRESERVATION / BISPECIES AND SMALL SPOROMORPHS COMMON

LOCATION MAP

