REPORT EP-54927

PALYNOFACIES INVESTIGATION IN THE JURASSIC INTERVAL OF THE NORSKE SHELL WELL 31/2-5

by

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SIPM EP/12

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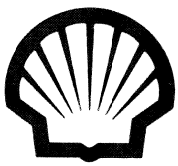


EXPLORATION AND PRODUCTION

CONTENTS

ILLUSTRATIONS

SUMMARY

A palynofacies analysis of the post Pliensbachian Jurassic strata of the Norske Shell well 31/2-5 was undertaken to aid in the interpretation of the depositional environments of the Norwegian 31/2 block area.

Seven palynofacies sequences are discussed, many of which are related to a series of prograding units. The lower parts of some sequences, usually associated with silty shales, silt and fine sandstones, display quite extended intervals indicating a distal marine offshore environment. The upper, more sandy parts of these sequences display often a sharp change to higher energy conditions probably in a lower shoreface or shoreface setting. The 'reservoir sands' of the Late Oxfordian indicate considerable time in transport before final deposition along a probable linear non-deltaic shoreline. Other sands of Middle Callovian age (lower part) appear to represent rapid sedimentation, possibly close to a river mouth. During Aalenian/Bajocian times, palynofacies indicate the upper part of this sequence included sediments deposited in lagoonal or large lacustrine like environments, suggestive of a lower delta plain setting.

A comparison of palynofacies from adjacent wells, indicates well 31/2-5 is situated generally in a more offshore setting to those of wells 31/2-1, 2, 3 and 6.

KEY WORDS

31/2-5, 31/2-1, 31/2-2, 31/2-3, 31/2-6, 31/4-2, palynofacies, Norway, North Sea, offshore, environments, Jurassic, deltaic, dinoflagellates, sporomorphs, microplankton, palynodebris.

1. INTRODUCTION

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

In the present report a slightly modified terminology for some palynodebris types is employed, which is summarized as follows :

Dense woody material	=	Palynomaceral	1
Woody material	=	"	2
Epidermal material	=	"	3
Opaque material	=	"	4

The format for the chart used to display the distribution of the different palynological constituents has also been slightly modified to incorporate the above changes of terminology. These changes bring the terminology into line with recommendations suggested at recent Palynofacies Workshops.

2. RESULTS

The palynofacies study in the Jurassic interval from the Norske Shell well 31/2-5 included the analysis of 23 cores and 63 sidewall samples. From the character of the palynological constituents a number of palynofacies types could be identified, which could be further grouped into 7 palynofacies sequences. By applying basic sedimentological and palaeontological principles to the distribution of their constituents, an environmental interpretation is suggested for each of these sequences.

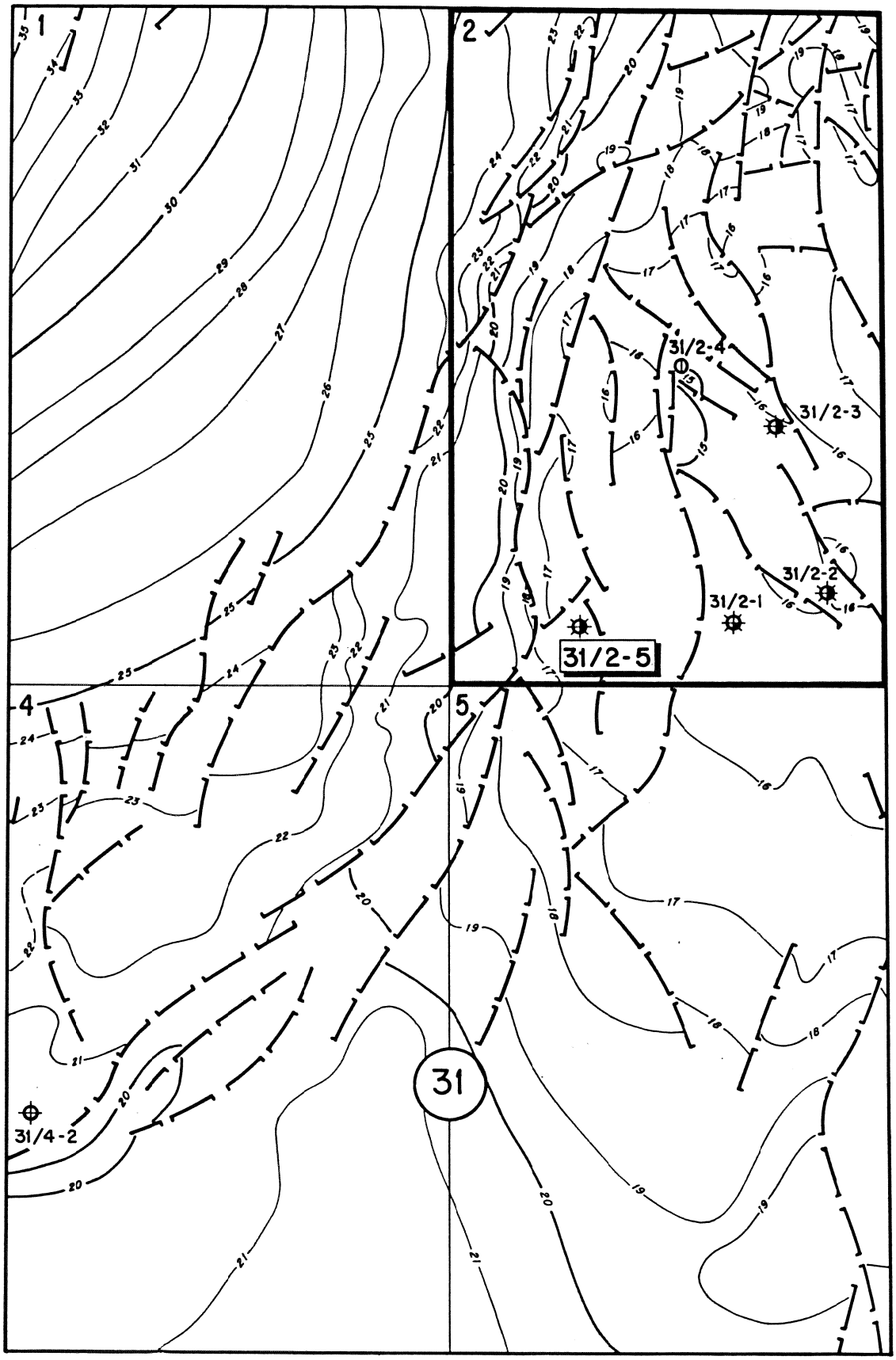


FIGURE 1

GENERAL LOCATION MAP

(Base Cretaceous play map 1: 250 000)

REPORT No.: EP - 54927 DRAWING No.: G. 66251/1

SEQUENCE 1

Interval : 2163.8-2017.0 m

Age : Toarcian - Aalenian/Bajocian

Description

Palynofacies types I/II in the lower part of the sequence are characterized by high proportions of structureless (sapropelic) organic matter, together with minor proportions of blade shaped small or medium sized material comparable to palynomaceral 2 (= woody material). Dinocysts (2 types) are infrequent. A low number of small sized bisaccates and other small buoyant sporomorphs are present. Significant, is the co-occurrence of a number of large leiosphaeroids.

Palynofacies types III/IV from the middle part of the sequence are characterized by a high proportion of bisaccates and other buoyant sporomorphs, together with a low proportion of less buoyant small material comparable to palynomaceral 1 (= dense woody material), and palynomaceral 4 (= opaque material). Dinocysts (usually 2 or 3 types) are frequent or common.

Palynofacies type V from the upper part of this sequence contain proportions of small, medium and large sized material comparable to palynomacerals 1, 2 and 3. Bisaccates and other sporomorphs occur only in minor proportions, together with low amounts of small and medium sized material of palynomaceral 4. Dinocysts are (often 2 or 3 types) usually frequent.

Discussion

Palynofacies types I/II from the lower part of this sequence are most comparable to those observed from the Kimmeridgian "oil shales" and probably indicate a similar offshore marine setting with relatively anoxic (stagnant) bottom water conditions. Sediments from this interval are probably of source rock quality with a high potential to yield oil, when maturity has been reached.

Palynofacies from the middle part of this sequence indicate a similar offshore lower marine environment, generally distal to any terrestrial supply of organic material. The absence of structureless (sapropelic) organic matter, however, indicates bottom water circulation was not resctricted. The absence of significant proportions of palynomaceral 4, and the relatively good preservation of the terrestrial elements (bisaccates, other sporomorphs, etc.) may also indicate absence of any strong current activity at the sea bottom, and the absence of bioturbation.

Palynofacies V from the upper part of the sequence indicate a marine upper offshore environment, proximal to a source of terrestrial organic matter.

Environmental interpretation

Upper part of the sequence	:	marine upper offshore
Middle part of the sequence	:	marine lower offshore
Lower part of the sequence	:	marine lower offshore, with restricted bottom circulation

SEQUENCE 2

Interval : 2001.2-1967.1 m

Age : Possibly Aalenian/Bajocian

Description

Palynofacies types XIII/XII from the lower and middle part of this sequence are characterized by the high proportion and diversity of sporomorphs. The sporomorphs are dominated by the fern spores and species of Classopollis. The lower palynofacies at 2001.2 m is also characterized by a high proportion of large pieces of a pale, flimsy, structureless tissue, and a few dinocysts.

The uppermost palynofacies type VII is characterized by high proportions of medium and large sized material comparable to equidimensional and blade palynomaceral 4. Dinocysts, bisaccates and other sporomorphs were not observed.

Discussion

Palynofacies from the lower part of the sequence suggest a large open expanse of water which is almost enclosed from the area, but still receives some marine influence. The presence of a high proportion and diversity of sporomorphs, dominated by fern spores and Classopollis indicates close proximity to shore, but absence of palynomacerals 1-3 suggests little direct fluvial input. These latter features together with rare dinocysts are most compatible with a large sized lagoon. The predominance of structureless large pale tissue may indicate the growth of some form of aquatic algae or flora, thus suggesting an enclosed, protected low energy setting.

The absence of dinocysts in the palynofacies XIII/XII above may suggest the marine influence was entirely cut off in this upper part of the sequence.

The uppermost palynofacies is characterized by the most resistant of palynomacerals. The absence of other palynological constituents indicates very high energy conditions, in an environmental setting unsuitable for dinocysts, and with little input of terrestrial organic material. These associations often characterize high energy shoreface settings lateral to any direct terrestrial supply, or fluvial channel sands.

Environmental interpretation

Upper part of sequence	:	shoreface, lateral to a terrestrial supply/or fluvial channel.
Lower & middle parts of sequence	:	?lagoonal/lacustrine-large.

SEQUENCE 3

Interval : 1955.5-1812.0 m

Age : Middle Bathonian-Early Callovian

Description

The palynofacies types III and IV from the lower part of this sequence are characterized by high proportions of bisaccates and other buoyant sporomorphs, low proportions of small sized material of palynomacerals 1-3, and a moderate diversity (4-19 types) and frequency of dinocysts.

Palynofacies types V and V^B from the middle part of this sequence are characterized by the high proportions, often poorly preserved, large, medium and small sized material of palynomacerals 1, 2 and 3. Bisaccates and other sporomorphs occur only in low proportions. Dinocysts are diverse (8-14 types) and common.

A palynofacies comparable to type $VIII^R$ above the middle part of the sequence, at 1836.6 m, is characterized by the rounded nature of its debris similar to palynomacerals 1 and 2. Sporomorphs are very rare, and poorly preserved. Dinocysts, however, are relatively diverse (11 types) and frequent.

Palynofacies types VII and VI from the uppermost part of this sequence are characterized by a high proportion of darkened large, medium and small sized material of palynomacerals 1 and 2. Bisaccates and other sporomorphs are present in low proportions. Material comparable to palynomaceral 4 was not observed. Dinocysts are present in moderate amounts and diversity (10-11 types).

Discussion

In general this sequence seems to represent a marine environment, beginning offshore and relatively distal to a source of terrestrial organic material, becoming shallower and nearer shore in the middle part of the sequence, and then possibly close to shore or shoreface in the uppermost part.

The poor preservation of the palynomacerals in the middle part of the sequence might indicate the effects of bioturbating infauna at this level. Higher in the sequence rounding and darkening of the palynomacerals may indicate low rates of deposition and possibly that the supply of terrestrial organic debris was some distance away.

Environmental interpretation

Upper part of sequence	:	shoreface/lower shoreface
Middle part of sequence	:	offshore upper
Lower part of sequence	:	offshore lower

SEQUENCE 4

Interval : 1799.5-1766.0 m

Age : Middle Callovian

Description

Palynofacies types III and IV in the lower part of the sequence are characterized by high proportions of bisaccates and buoyant sporomorphs, low proportions of small sized palynomacerals 1-3, together with a moderate/high diversity (18-34 types) and frequency of dinocysts.

Palynofacies from the upper part of this sequence are characterized by their intermediate nature between types V and XI. The palynodebris includes high proportions of large, medium and small sized, well and often excellently preserved material of palynomacerals 1, 2 and 3. Bisaccates and other sporomorphs, also of good preservation, are present in low proportions. Dinocysts are usually rare or infrequent, and relatively low in diversity (9-10 types). Dinocysts are absent from the uppermost sample.

Discussion

The preservation and nature of palynodebris associated, particularly with the upper part of this sequence, is very characteristic and can be recognized as a separate unit, at a similar stratigraphic horizon, in 31/2-1 (interval : 1610.95-1640.65), 31/2-2 (interval : ± 1765.0 m), and over a much wider interval in 31/2-3 (interval : 1521.7-1621.0 m). A brief survey of 31/2-6 indicates this type of palynodebris was penetrated at 1715.0 m, and may still be present at 1740.0 m.

The above sequence of palynofacies most likely represents in the lower part an offshore lower marine environment, and in the upper part an offshore upper or lower shoreface type of setting, but probably at the mouth of a fluvial distributary, discharging great quantities of organic material. The excellent preservation of the palynodebris suggests deposition was rapid and the sedimentation rate high.

Environmental interpretation

Upper part of sequence	:	offshore upper/shoreface lower type setting, at a river mouth.
Lower part of sequence	:	offshore lower.

SEQUENCE 5

Interval : 1760.5-1695.5 m

Age : Middle Callovian

Description

The above sequence can be subdivided into three sub-sequences each with a similar development of palynofacies types. The lower part of these sub-sequences are characterized by palynofacies V with high proportions of large, medium and small sized material comparable to palynomacerals 1, 2 and to a lesser extent 3. Preservation of the palynodebris is relatively poor. Preservation in the uppermost sub-sequence is good (for palynofacies V). Bisaccates and other sporomorphs occur in moderate or low proportions. Dinocysts occur usually in low proportions but may be of moderate diversity (14-22 types). Disassociated chambers of ?microforam test linings are also common. Small spinose acritarchs in some assemblages are present.

The upper part of the subsequences are characterized by palynofacies types VII and IX. Palynofacies VII is characterized by high proportions of large, medium and small material of palynomaceral type 1. Bisaccates, other sporomorphs and microplankton are rare. Palynofacies IX from the lower subsequences are characterized by rounded and darkened material of palynomaceral type 1. In the upper subsequences the debris is small but more mixed with palynomacerals 2 and 3, bisaccates and other sporomorphs. Microplankton was not observed.

Discussion

In general the three subsequences (which coincide with high to low gamma ray readings) represent in their lower part an offshore upper/ shoreface lower marine environment, and in the upper part a shoreface (high energy) and almost beach like setting.

The relatively poor preservation of the debris occurring in this sequence, may suggest the rate of sedimentation was low, relative to sequence 4.

Environmental interpretation

Three subsequences representing in their

upper part : high energy (shoreface - "beach like")

lower part : shoreface lower/offshore upper

SEQUENCE 6

Interval : 1693.5-1567.30 m

Age : Late Callovian-Late Oxfordian

Description

Palynofacies types III & IV from the lower part of this sequence (1693.5-1648.65 m) are characterized by high proportions of bisaccates and other buoyant sporomorphs, low proportions of small sized material of palynomacerals 1-3 types, together with a high diversity (17-27 types) and frequency of dinocysts. Disassociated chambers of ?microforam test linings are also common. Palynomaceral 4 of blade and equidimensional shape appears in significant proportions from 1684.5 m upwards.

Palynofacies from the upper part of this sequence are characterized by very high proportions of blade shaped palynomaceral 4, low proportions of poorly preserved and broken bisaccates, and rare/infrequent occurrence of microplankton. A very low proportion of debris comparable to palynomaceral 1 may be present, but is extremely degraded and rounded. Equidimensional shaped, large sized material of palynomaceral 4 is present conspicuously only in one sample.

Discussion

The lower part of this sequence probably represents a marine offshore lower environment. Within this lower sequence can be observed the incoming of palynomaceral 4 type material in significant proportions from 1684.5 m upwards. This is a feature recognizable throughout the northern Viking Graben area and appears to co-occur with a sudden and marked change in the palaeogeographical setting at the base of the Late Callovian (Lamberti zone). As discussed in the report of 31/2-1 and 2 (report EP-53031) this event is probably related to a regional transgression associated with the opening up of the North Atlantic Ocean. In the area of 31/2-5 it appears that at the time of this transgression marine offshore conditions were maintained, but that energy conditions at the sea bottom increased.

In the upper part of this sequence palynofacies type VII contains only small proportions of material comparable to palynomacerals 1-3, and high proportions of blade shaped material of palynomaceral type 4. This may be the result of high energy conditions, some distance from a source of terrestrial organic material, which would concentrate only the most resistant material. Such an environmental setting occurs along the shoreface of a coast away from active fluvial distributaries. Very thin coaly layers occurring in this part of the sequence are probably isolated pieces of drifted, resistant wood.

Environmental interpretation

Upper part of sequence	:	shoreface - away from any terrestrial organic material (non-deltaic "linear" shoreline)
Lower part of sequence	:	offshore lower

SEQUENCE 7

Interval : 1563.7-1539.85 m

Age : Late Oxfordian

Description

Palynofacies types comparable to IV and V characterize the lower part of this sequence. The palynodebris includes a high proportion of blade shaped material of palynomaceral type 4, together with bisaccates. Dinocysts occur frequently, but their diversity is lower relative to sequence 6. Material comparable to palynomacerals 1 and 2 is also more conspicuous than in sequence 6.

Palynofacies type VII from the upper part of this sequence are characterized by a high proportion of blade shaped material of palynomaceral 4 type together with a significant proportion of relatively well preserved material comparable to palynomacerals 1 and 2.

Discussion

The lower part of the above sequence probably represents a very near shore (lower shoreface/shoreface) environmental setting. The slightly higher proportion of palynomacerals 1 and 2 indicates a closer proximity to a terrestrial supply of organic material than during sequence 6 times, albeit still some distance away.

Environmental interpretation

Lower shoreface - shoreface (possibly non deltaic "linear" shoreline).

3. CONCLUSIONS

By applying principles described in report EP-53031, the following general environmental interpretation of the Jurassic interval of the Norske Shell well 31/2-5 is suggested (see figure 2) :

From the nature of the different palynofacies types identified, 7 palynofacies sequences can be recognized, which can be shown to represent a series of prograding units.

- Sequence 1, approximately corresponding with the Toarcian interval, reflects essentially a gradual increase of the energy conditions at the sea bottom. The basal part of this sequence was probably of a marine lower offshore environment, with restricted circulation at the sea bottom. This part of the sequence is very comparable to the environmental setting established during the times of the "Kimmeridgian oil shale". Similar palynofacies have also been recognized from the basal part of the Toarcian interval in 31/2-1, 2 and 3 and 31/4-2. Circulation at the sea bottom in these areas, however, was perhaps less restricted.

  Towards the upper part of sequence 1 in 31/2-5, there is evidence to indicate that circulation at the sea bottom improved, possibly due to shallowing, followed in the uppermost part by the distant approach of a terrestrial supply of organic material.

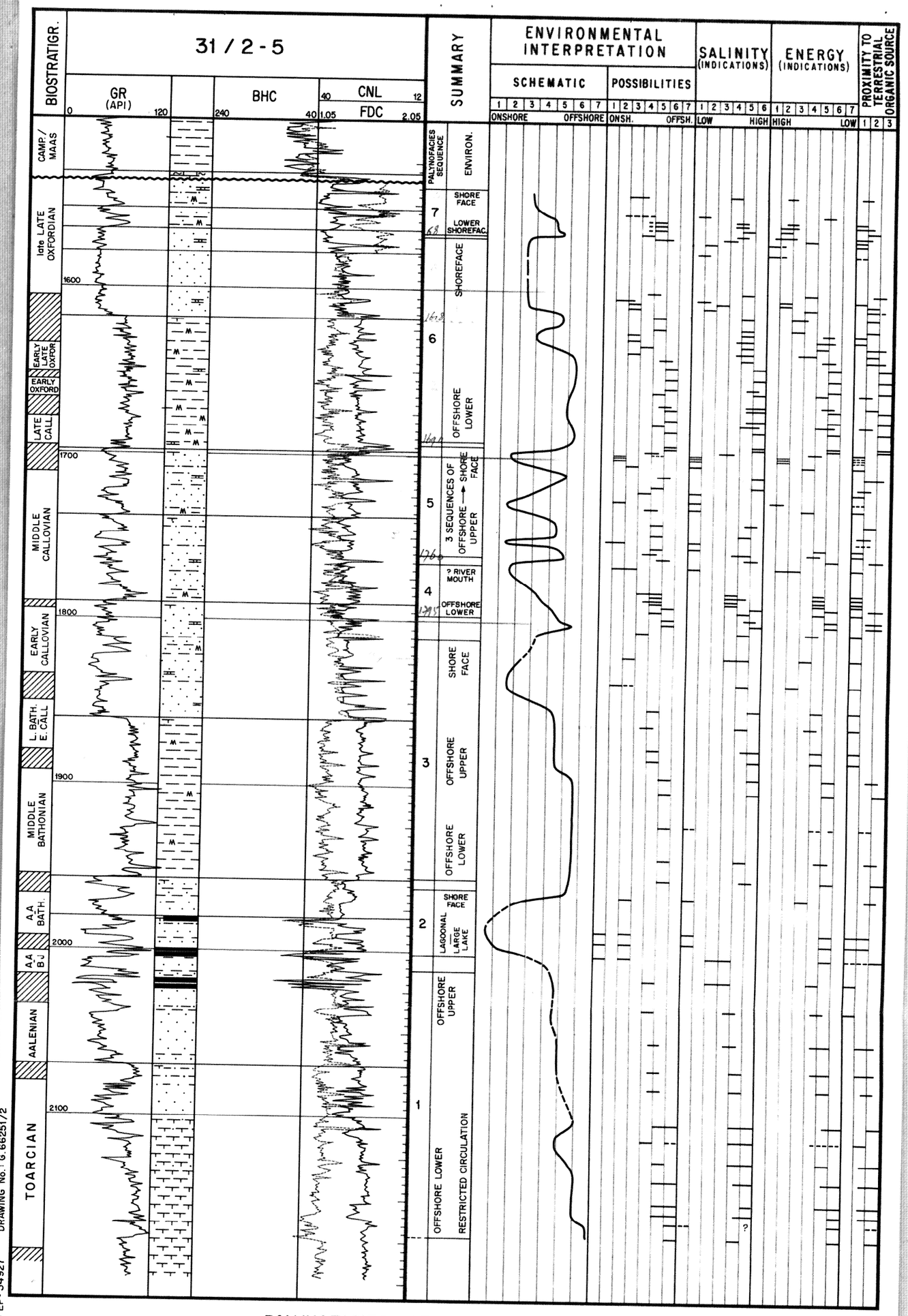
- Sequence 2, of probable Aalenian/Bajocian age, represents a progradation began in the previous sequence, which includes in its upper part, palynofacies typical of lower delta plain. A similar series of palynofacies can be recognized in 31/2-1, 2 and 3. In the present well, however, a greater part of the lower part of this sequence is marine influenced, and in the upper part there is more indication of lagoonal or large lacustrine like sediments.

- Sequence 3 has its base in the Middle Bathonian and in this lower part contains palynofacies indicating a low energy marine offshore lower environment, followed by a more shallow, bioturbated and near shore middle part, with an upper part (Early Callovian) suggestive of shoreface. Palynofacies of Middle Bathonian age from the wells 31/2-1, 2 and 3 indicate that these areas were clearly more proximal to a shore line during this interval. Palynofacies from the Bathonian interval of 31/4-2 which indicate a distal offshore lower environment, are more comparable.

- Sequence 4 of Middle Callovian age represents again a prograding sequence, indicating a gradual change from marine offshore lower conditions at its base, to offshore upper or perhaps a shoreface like setting subjected to very low wave energy, situated very close to a river mouth. The character of the palynodebris indicates that at the time this sequence was deposited, the sedimentation rate was probably very high. The Middle Callovian interval of adjacent wells 31/2-1, 2 and 3, also indicates palynofacies which suggest periods of high sedimentation rates. The nature of the palynodebris in 31/2-5,however, suggests the rate was relatively higher there.

- Sequence 5, also of Middle Callovian age, may be subdivided into at least three minor prograding sequences. The source of terrestrial supply appears to have been transferred away from this area, and during this interval the site of 31/2-5 was lateral to any major distributary (a non-deltaic linear shoreline). Each prograding unit within this sequence appears to represent a minor change from upper offshore to lower shoreface, their upper part possibly representing sediments brought in by storm action. The sedimentation rate during this interval appears to be relatively lower than observed in sequence 4.

- Sequence 6 spans a time interval from Middle Callovian to Late Oxfordian. During much of this time the site of 31/2-5 remained offshore distal to any major influence of terrestrial input. In the upper part of this sequence the environment changed during the Late Oxfordian. A series of sands were deposited in this area, and from their palynodebris it would seem most likely in a relatively high energy environment, possibly lower shoreface. The character of the palynodebris also indicates these sands to have spent a considerable length of time in transport, and their original source to have been some distance away. A brief comparison of the palynodebris contained in the Late Callovian-Oxfordian sands bearing a similar gamma ray response in 31/2-2, 3 and 6 indicates these latter wells to be probably closer to the original source area at this time. This is also supported by the fact that the base of these sands are of an older (Early Oxfordian) age, to the east generally. In the lower part of this sequence palynofacies also indicate 31/2-5 to be situated in a more offshore setting than the adjacent wells 31/2-1, 2, 3 and 6.



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PALYNOFACIES SEQUENCES AND THEIR
SUMMARIZED ENVIRONMENTAL INTERPRETATION IN 31 / 2 - 5

(FOR KEY, SEE PAGE 13)

Fig. 2

- Sequence 7, in the uppermost Jurassic of the present well, begins with a brief return to lower energy conditions. The microplankton content, however, suggests the environment may have been still close to shore. The sands in the upper part of this sequence appear to have been deposited in a similar lower shoreface setting to those of the upper part of sequence 6. There is however evidence from the character of the palynodebris to suggest that these sands have spent less time in transport (relative to sequence 6) and may have been relatively closer to their source.

In general it can be seen that marine offshore conditions, represented by the finer grained sediments in the lower part of most sequences, are more well established, and for longer intervals in the area of well 31/2-5, relative to adjacent wells in the 31/2 Block to the East. The sands occurring in the upper parts of the prograding units appear to have been deposited in environments either close to a major distributary, or as highly winnowed sands transported possibly along a linear non-deltaic shoreline, some distance away from their original source, or as pulses of sediments probably derived from storm processes.

The particularly restricted nature of the bottom water circulation during the early part of the Toarcian period and the high rate of sedimentation suggested during Middle Callovian times, may be indicative that this area was subsiding relative to adjacent areas. This subsidence might be a consequence of a horst/graben pattern of structural activity.

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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. Leiosphaeroids (small)
3. Microplankton monospecific
4. Low diversity/simple morphology
5. Moderate diversity
6. High diversity/complex morphology

ENERGY (Indications)

1. Tiny/small material of palynomaceral 4
2. Tiny/small material of palynomacerals 1 & 4
3. Rounded/rolled constituents
4. Large material of palynomacerals 4/1
5. Large-small material of palynomacerals 2/3
6. Small material of palynomacerals 4/2/3 + bisaccates
7. S.O.M.

PROXIMITY (Indications)

1. Large constituents/good preservation/monospecific spore assemblages
2. Intermediate
3. Small buoyant constituents/poor preservation/bisaccates and small sporomorphs common.

REPORT No.: EP-54927 DRAWING No.: G.66251/3

STRATIGRAPHY	SAMPLE DEPTH	TYPE	SOM					MARINE PALYNOMORPHS (ORGANIC WALLED)										TERRESTRIAL PALYNOMORPHS										DEBRIS OF MAINLY PLANT ORIGIN																						PALYNOFACIES TYPE	ENVIRONMENTAL INTERPRETATION
			MISCELLANEOUS	SEMI-SOM	SMALL/DARKENED	LARGE CLUSTERS	UNDIFFERENT.	MARINE PALYNOMORPHS		MICROF. TESTLININGS	MARINE ALGAE	ACRITARCHS		DINOCYSTS				TERRESTRIAL PALYNOMORPHS		BISACCATES				FRESH WATER ALGAE	FUNGAL SPORES	SPOROMORPHS (NON-SPECIFIED)				PALYNOMACERAL 4								PALYNOMACERAL 1,283		PALYNOMACERAL 3				PALYNOMACERAL 2				PALYNOMACERAL 1					
												SPINOSE	LEIOSPH.	No. DOM. TYPES	DIVERSITY									NON-BUOYANT	BUOYANT	No. OF DOMINANTS	DIVERSITY		BLADE NEEDLE				EQUI-DIMEN.																							
				TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	DEGRADATION	BROKEN	TOTAL	TOTAL	LARGE	SMALL	TOTAL	LARGE	MEDIUM	SMALL	TOTAL	DEGRADATION	BROKEN	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	TOTAL	TOTAL					LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	DEGRADATION	ROUNDING	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE 100+	MEDIUM 50-100	SMALL 0-50	UNDIFFERENTIATED*		
late LATE OX.	1541.60	CORE							C	20					2	L	5	G		2	1	2				1	2	L					25	25		G						1						5			V	Offshore upper
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"	1552.12	"																											1	2	2			3	2													10	75	5		VII	Shoreface
"	1555.85	"		3						5						L	3		C							1	1			3	3	4		5	7	8		B					3	2			20	20	10		V	Offshore upper
"	1556.63	"							C	10		1			2	M	4			3	3	4				2	3		L		3	3	4		6	6	8			M							5	20	5		V	Offshore upper
"	1559.65	"							C	5		1					5			5	5	5				2	3		M		5	5	5		30	5	5							2	3				5	5		IV	Offshore lower
"	1562.65	"								2		1				L	5			1	1	1				1	1		L		6	6	8		20	15	15							2	3				1	2		VII	Shoreface
"	1563.78	"							G	M	8					L	2	G		3	3	4				2	3		L		1	2	2		10	5	5		P					2	3			10	20	20		V	Offshore upper
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"	1601.20	"								5		1					5			2	3	2				1	2		M		3	3	4			7	8		G				5		10	15	5		5	5	5		V	Offshore upper
"	1603.25	"								2							<1				1						5		L		1	1	3			10	10		P	M						5			20	30	10		VII	Shoreface
"	1603.55	"																									1		L		2	3	5		35	20	20						2						5	5		VII	Shoreface
"	1606.95	"								1				<1			1				1						1				5	5	5		20	20	20		M							5			5	5	5		VII	Shoreface
"	1614.75	"							C	5						M	3	G		10	10	5				3	2		L			3	2			3	2		M							5	5		10	30	10		V	Offshore upper
"	1618.80	"							C	4						M	5			6	6	8					2		L		2	2	1		10	3	2									3	2		10	30	10		V	Offshore upper
"	1623.85	"								1					2	M	5			2	2	1				3	2		L		6	6	8		15	20	20									3	2			3	2		VII	Shoreface
"	1626.55	"							C	1		1					3				1										5	5	5		40	10	10									5	5			10			VII	Shoreface
"	1631.85	"							C	2		1					5			2	2	2				3	2		L			1	1			4	4		P							5	5		10	30	20		VI	Shoreface lower
early LATE OX.	1638.60	"								5		1				L	<1			1	3	1									15	16	17											5	20	5			3	2		VII	Shoreface
"	1643.90	"							C	2		2					5			5	5	5									3	3	4			10	10		M							10	20	10			10	5		V/IV	Offshore upper/lower
"	1648.15	"							M	C	1		<1		2	M	8	M	C	5	5	10				3	2		L		1	3	1			10	15		M			5				10	20	10				5		III/IV	Offshore lower
"	1650.55	"								C	1		1			H	8	M	C	6	6	8				3	2		L		3	3	4		6	6	8				2	2	6			5	20	10						III/IV	Offshore lower
EARLY OXF.	1657.30	SWS							M/P	C	5					M/H	3	M/P	C		5	15				2	10		M			10	10			10	10		P	R							5				15		IV	Offshore lower
"	1659.50	"							M/G	R	1					M/H	3			3	4	4				7	7		M			3	2			5	5		M	R						3	10	15		3	10	15		V	Offshore upper

DISTRIBUTION OF PALYNOLOGICAL CONSTITUENTS - TABLE 1

REPORT No.: EP-54927 DRAWING No.: G.66251/4

STRATIGRAPHY	SAMPLE DEPTH	TYPE	MISCELLANEOUS	SOM				MARINE PALYNOMORPHS (ORGANIC WALLED)								TERRESTRIAL PALYNOMORPHS						FRESH WATER ALGAE	FUNGAL SPORES	SPOROMORPHS (NON-SPECIFIED)				DEBRIS OF MAINLY PLANT ORIGIN																				PALYNOFACIES TYPE	ENVIRONMENTAL INTERPRETATION
				SEMI-SOM	SMALL/DARKENED	LARGE CLUSTERS	UNDIFFERENT.	MARINE PALYNOMORPHS	MICROF. TESTLININGS	MARINE ALGAE	ACRITARCHS		DINOCYSTS			TERRESTRIAL PALYNOMORPHS	BISACCATES										PALYNOMACERAL 4								PALYNOMACERAL 1,2&3		PALYNOMACERAL 3			PALYNOMACERAL 2				PALYNOMACERAL 1					
			TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	DEGRADATION	BROKEN	TOTAL	TOTAL	SPINOSE	LEIOSPH.	No. DOM. TYPES	DIVERSITY	TOTAL	DEGRADATION	BROKEN	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	TOTAL	TOTAL	NON-BUOYANT	BUOYANT	No. OF DOMINANTS	DIVERSITY	UNDIFFERENTIATED*	BLADE NEEDLE LARGE	BLADE NEEDLE MEDIUM	BLADE NEEDLE SMALL	BLADE NEEDLE UNDIFFERENT.*	EQUI-DIMEN. LARGE	EQUI-DIMEN. MEDIUM	EQUI-DIMEN. SMALL	EQUI-DIMEN. UNDIFFERENT.*	DEGRADATION	ROUNDING	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE 100+	MEDIUM 50-100	SMALL 0-50	UNDIFFERENTIATED*		
EARLY OXFORD.	1664.20	SWS						M/G		1					M	1	M/P	M		6	10				5	15		M			5	5				5	5					1			6	15			5	15		V/IV	Offshore upper/lower
" "	1668.50	"						M/G	C					1	M	5	G	M	5	10	5				10	15		M			3	2				3	2		P						2	18			2	18		IV	Offshore lower
LATE CALL.	1677.50	"													H	16				10	5				10	10		M								8	7		M/G	R					2	15			2	15		IV	Offshore lower
" "	1678.50	"						M	M						M	1	M	M		6	10				7	10					4	4				4	4		M/G	R		5	5		5	5	10		5	5	10		V	Offshore upper
" "	1684.50	"						M			1				M	<1				5	20				10	5		H/M		2	5	5			3	2		G/M	R		1	5				15			1	20		IV	Offshore lower
" "	1692.50	"						G/M	C	?10						1	M	M		10	25				10	25											1		G/M	R						5					13		III[B]	Offshore lower
" "	1693.50	"						M/P	C	?5					M	1	M/P	C		8	25				10	25										3	2				1	1	5			2	5			2	5		IV	Offshore lower
" "	1695.50	"						P	C	1					L	1					1				1	5													B	R		1			5	5	10		10	30	30		VII/V	? Shoreface lower
" "	1696.50	"															M/P	M	10	2	2				4	4		M														5	5		5	15	20			8	20		V/IX	Offshore upper -v. high energy
	1698.60	"															M/P	M	10	2	2				4	4		M														5	5		5	15	20			8	20		V/IX	" "
	1703.50	"															M/P	M	10	2	2				4	4		M														5	5		5	15	20			8	20		V/IX	" "
	1706.00	"															M/G	R		1					1	1																			1	1			30	30	35		VII	Shoreface
MIDDLE CALL.	1713.00	"						G	R	?5				1	H	3	G	R	5	10	5				7	10										1	1		M	R					2	10	15		1	10	15		IV/V	Offshore lower/upper
" "	1718.50	"										1			H	1	G	R		6					2	6													G	R		6	10		10	20	10				26		V	Offshore upper
" "	1721.00	"															M	M	2	5					2	2		M											G/M	R	2	2	2		12	20	20			10	20		V/VII	? Shorface lower
" "	1727.50	"																			1														5	5			B	C										89		IX	v. high energy
" "	1730.30	"								2										2					1	2													B						3	10	24			25	30		V/VI	? Shorface lower
" "	1735.50	"						G	M	3		1			H	1	M/P	M	1	10	5				3	5													M/P	R						5	23			10	33		V	Offshore upper
" "	1747.50	"						M	C							1			10	12	1				2	10													P	M						2	20			2	40		V	Offshore upper
" "	1750.00	"						M/G	C	10							P	C			1					1					3	2			3	2			P	C							8			70		IX[S]	v. high energy
" "	1754.50	"														1?			1	2	1				2	2		M											P/M	R						5	10	24		5	45		V	Offshore upper
" "	1756.50	"								?5					M	1				5					2	2													G	R						5	10	25		10	35		V/VII	? Shoreface lower
" "	1760.50	"								10		1			M/H	1	M/G	M	10	20	5				5	5																					10			34		V/IV	Offshore upper/lower
" "	1766.00	"																																					M	C							40			60		VIII/IX	Offshore upper/lower
" "	1782.00	"													M	<1	M/G	M	5	5					3	3													G	R	5	4	5			10	10	10		10	30		V/XI	? River mouth

DISTRIBUTION OF PALYNOLOGICAL CONSTITUENTS - TABLE 2

REPORT No.: EP - 54927 , DRAWING No.: G. 66251 / 5

STRATIGRAPHY	SAMPLE DEPTH	TYPE	MISCELLANEOUS	SOM				MARINE PALYNOMORPHS (ORGANIC WALLED)									TERRESTRIAL PALYNOMORPHS										DEBRIS OF MAINLY PLANT ORIGIN																				PALYNOFACIES TYPE	ENVIRONMENTAL INTERPRETATION
				SEMI - SOM	SMALL / DARKENED	LARGE CLUSTERS	UNDIFFERENT.	MARINE PALYNOMORPHS	MICROF. TESTLININGS	MARINE ALGAE	ACRITARCHS		DINOCYSTS			TERRESTRIAL PALYNOMORPHS	BISACCATES				FRESH WATER ALGAE	FUNGAL SPORES	SPOROMORPHS (NON-SPECIFIED)				PALYNOMACERAL 4								PALYNOMACERAL 1,2&3		PALYNOMACERAL 3				PALYNOMACERAL 2				PALYNOMACERAL 1					
											SPINOSE	LEIOSPH.															BLADE NEEDLE				EQUI-DIMEN.																			
			TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	DEGRADATION	BROKEN	TOTAL	TOTAL	LARGE	SMALL	No. DOM. TYPES	DIVERSITY	TOTAL	DEGRADATION	BROKEN	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	TOTAL	TOTAL	NON - BUOYANT	BUOYANT	No. OF DOMINANTS	DIVERSITY	UNDIFFERENTIATED*	LARGE	MEDIUM	SMALL	UNDIFFERENT.*	LARGE	MEDIUM	SMALL	UNDIFFERENT.*	DEGRADATION	ROUNDING	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE 100+	MEDIUM 50-100	SMALL 0-50	UNDIFFERENTIATED*		
MIDDLE CALL.	1783.00	SWS						G	M			1				1	G/M	M/R	2	5					2	5												G	R	10	10	20		10	10	10			5	10		V/XI	? River mouth
" "	1785.50	"								?1						<1	G	R	2	2	2				5	5		M										G	R	8	10	20		5	10	10		5	5	10		V/XI	River mouth
" "	1787.00	"						G	R						M	<1	G	M	2	3	1				2	2								1				G	R	20	18	10		10	10	10		1	5	5		V/XI	River mouth
" "	1789.00	"						G	R			1			H	1	G	R		20	20				5	35					5	5						G	R	1	2	1				2						III	Offshore lower
" "	1792.50	"						G	M			1			M	1			2	3	2					8														5	15	5		15	15	5		2	15	5		V	Offshore upper
EARLY CALL.	1796.70	"						G								1	G	M	10	25	15					20		M						2	1		G	R	2	2	2		2	2	10			2	5		III	Offshore lower
" "	1799.50	"						M	M	1		1				1	M	M	5	10	10				5	20												P	M			10			2	10			2	20		III / IV	Offshore lower
" "	1812.00	"						M	C	?2				1	L/M	1	M	M/C	2	4	2				1	5												B	M					2	12			10	30	30		VII / VI	Shoreface
" "	1820.70	"								?1					M/H	<1	M	M/C	2	4	2				1	5												B	M					2	12			20	30	20		VII	Shoreface
" "	1836.60	"													M/H	1	P	C							1	1												P	C					8	30				10	50		VIII^{R}/IX^{S}	? Shoreface
LATE BATH. / EARLY CALL.	1852.70	"						M	M					1	M	5	P	M	3	3	3				2	8							3	2				P	R			2			6	25			6	25		V^{B}	Offshore upper
" "	1861.70	"														3				2					2	10																		5	5	20		2	10	40		V/VI	Shoreface lower
" "	1877.00	"						M/G	M						M	2	P	C	2	2	2				2	5							3	2				P	R		5	5		5	5	20			5	30		V^{B}	Offshore upper
" "	1884.60	"													M	<1	P	C	1	1	1				2	2												B	R	1	2	5		2	5	40		1	5	30		V	Offshore upper
MIDDLE BATH.	1894.50	"										1		2	M	3				17	25					35							2	1				P	M			10			10				3		III	Offshore lower
" "	1903.40	"						G	R						H	10	M	M	5	10	10				5	25							3	2				M	M	1	1	10			1	10				2		IV	Offshore lower
" "	1924.40	"						P								<1	P	C	5	10	10				5	25							3	2				P	R	10	20	20		1	10					2		IV^{B}	Offshore lower
" "	1942.50	"						P	C						M	1	P	C	5	20	5				5	25							2	1				P	C		3	5			1	2			5	15		IV	Offshore lower
" "	1955.50	"						M/G	M						M	3	P	C	10	20	10				5	27							1	1				P	C			5				5				5		III / IV	Offshore lower
MIDDLE BATH. / AALENIAN	1967.10	"															G	R		3					2	5	1	M		5	3	2		40	15	15		B	C									10	10		VII	Shoreface
" "	1988.10	"																																3	2							1	4			15	15			20	30		XII / XIII	Lacustrine / lagoon
" "	1994.50	"									1						G	R	1						20	18	2	H			3	2			15	15		M/G	R	1	5	10				5				5		XIII	Lagoonal
AALEN. / BAJ.	2001.20	"						G	R					1	L	1			2	4	2				10	20	2	H						10	10	10				10	10	10										XIII	Lagoonal
" "	2017.00	"												1	L	<1				5					5	5		M		1	5	5			5	5		M/P	M/R		9	10			5	20			5	15		V	Offshore upper
AALENIAN	2035.10	"						G	R						M	1	M	M	10	5	2					20	1	M/L			3	2			3	2		M	R	1	5	15		3	7	11				10		V	Offshore upper

DISTRIBUTION OF PALYNOLOGICAL CONSTITUENTS - TABLE 3

REPORT No.: EP - 54927 DRAWING No.: G. 66251/6

STRATIGRAPHY	SAMPLE DEPTH	TYPE	SOM: MISCELLANEOUS	SOM: SEMI - SOM	SOM: SMALL/DARKENED	SOM: LARGE CLUSTERS	SOM: UNDIFFERENT.	MARINE PALYNOMORPHS (ORGANIC WALLED): MARINE PALYNOMORPHS DEGRADATION	MARINE PALYNOMORPHS: BROKEN	MARINE PALYNOMORPHS: MICROF. TESTLININGS	MARINE PALYNOMORPHS: MARINE ALGAE	ACRITARCHS: SPINOSE	ACRITARCHS: LEIOSPH.	DINOCYSTS: No. DOM. TYPES	DINOCYSTS: DIVERSITY	DINOCYSTS: TOTAL	TERRESTRIAL PALYNOMORPHS: TERRESTRIAL PALYNOMORPHS DEGRADATION	TERRESTRIAL PALYNOMORPHS: BROKEN	BISACCATES: LARGE	BISACCATES: MEDIUM	BISACCATES: SMALL	BISACCATES: UNDIFFERENTIATED*	FRESH WATER ALGAE	FUNGAL SPORES	SPOROMORPHS (NON-SPECIFIED): NON-BUOYANT	SPOROMORPHS (NON-SPECIFIED): BUOYANT	SPOROMORPHS (NON-SPECIFIED): No. OF DOMINANTS	SPOROMORPHS (NON-SPECIFIED): DIVERSITY	SPOROMORPHS (NON-SPECIFIED): UNDIFFERENTIATED*	PALYNOMACERAL 4: BLADE NEEDLE LARGE	PALYNOMACERAL 4: BLADE NEEDLE MEDIUM	PALYNOMACERAL 4: BLADE NEEDLE SMALL	PALYNOMACERAL 4: BLADE NEEDLE UNDIFFERENT.*	PALYNOMACERAL 4: EQUI-DIMEN. LARGE	PALYNOMACERAL 4: EQUI-DIMEN. MEDIUM	PALYNOMACERAL 4: EQUI-DIMEN. SMALL	PALYNOMACERAL 4: EQUI-DIMEN. UNDIFFERENT.*	PALYNOMACERAL 1,2&3: DEGRADATION	PALYNOMACERAL 1,2&3: ROUNDING	PALYNOMACERAL 3: LARGE	PALYNOMACERAL 3: MEDIUM	PALYNOMACERAL 3: SMALL	PALYNOMACERAL 3: UNDIFFERENTIATED*	PALYNOMACERAL 2: LARGE	PALYNOMACERAL 2: MEDIUM	PALYNOMACERAL 2: SMALL	PALYNOMACERAL 2: UNDIFFERENTIATED*	PALYNOMACERAL 1: LARGE 100+	PALYNOMACERAL 1: MEDIUM 50-100	PALYNOMACERAL 1: SMALL 0-50	PALYNOMACERAL 1: UNDIFFERENTIATED*	PALYNOFACIES TYPE	ENVIRONMENTAL INTERPRETATION
			TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	DEGRADATION	BROKEN	TOTAL	TOTAL	TOTAL	LARGE	SMALL	No. DOM. TYPES	DIVERSITY	TOTAL	DEGRADATION	BROKEN	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	TOTAL	TOTAL	NON-BUOYANT	BUOYANT	No. OF DOMINANTS	DIVERSITY	UNDIFFERENTIATED*	LARGE	MEDIUM	SMALL	UNDIFFERENT.*	LARGE	MEDIUM	SMALL	UNDIFFERENT.*	DEGRADATION	ROUNDING	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE	MEDIUM	SMALL	UNDIFFERENTIATED*	LARGE 100+	MEDIUM 50-100	SMALL 0-50	UNDIFFERENTIATED*		
AALENIAN	2054.70	SWS													M	1				5	15	5				3	25	1	L/M				5	5			3	2				2	10			2	15				5		IV/V	Offshore lower/upper
"	2071.40	"						G	R						H	1	M	C			17				2	18				1	8	7			3	2		M	R			10		1	5	15			2	10		IV/V	" " "
TOARCIAN	2081.70	"						G	R						H	5	M	M	5	10	5				5	20					8	7			5	5		P	R		5	10				5				5	IV/V	" " "
"	2104.80	"		10				G	R	1					H	2	G	R	5	10	5				5	20					5	5			3	2		G	R		5	10			5	5			3	10		IV/II	Offshore lower (restricted bottom water)
"	2113.00	"		3				G	M						H	1	M	M	2	5	2				2	10					3	2		5	3	2		G	M	2	2	5			10	20			5	15		V/II	Offshore upper (restricted bottom water)
"	2125.00	"						G	R					1	H	1	G	M			20					35					3	2			3	2		G	R	2	5	10			3	5			1	5		IV/III	Offshore lower (restricted bottom water)
"	2138.50	"		20				G	R						H	2	G	M			25					28					3	2			1	1		G	R						3	10				5		IV/II	" " "
"	2150.00	"		2				G	R						H	2	G	M			25					28					3	2			1	1		G	R	2	3	10			3	8				5		IV/II	" " "
"	2155.50	"		20				G	M						H	2	G	C			20					25					3	2						M	R		5	5			5	10				3		IV/II	" " "
"	2163.80	"				70							1													5															1	1			10	15						I/II	" " "
"	2171.00	"				86							1		M	<1					5					3																			3	2						I/II	" " "

LEGEND :

DIVERSITY
- V. LOW : L
- MEDIUM : M
- V. HIGH : H

No. OF DOMINANTS
- 1, 2, 3 etc.

DEGRADATION
- POOR : P
- MEDIUM : M
- GOOD : G
- CARBONIZED : B

ROUNDING
- V. COMMON : C
- MEDIUM : M
- RARE : R

BROKEN
- V. COMMON. : C
- MEDIUM : M
- RARE : R

DISTRIBUTION OF PALYNOLOGICAL CONSTITUENTS - TABLE 4

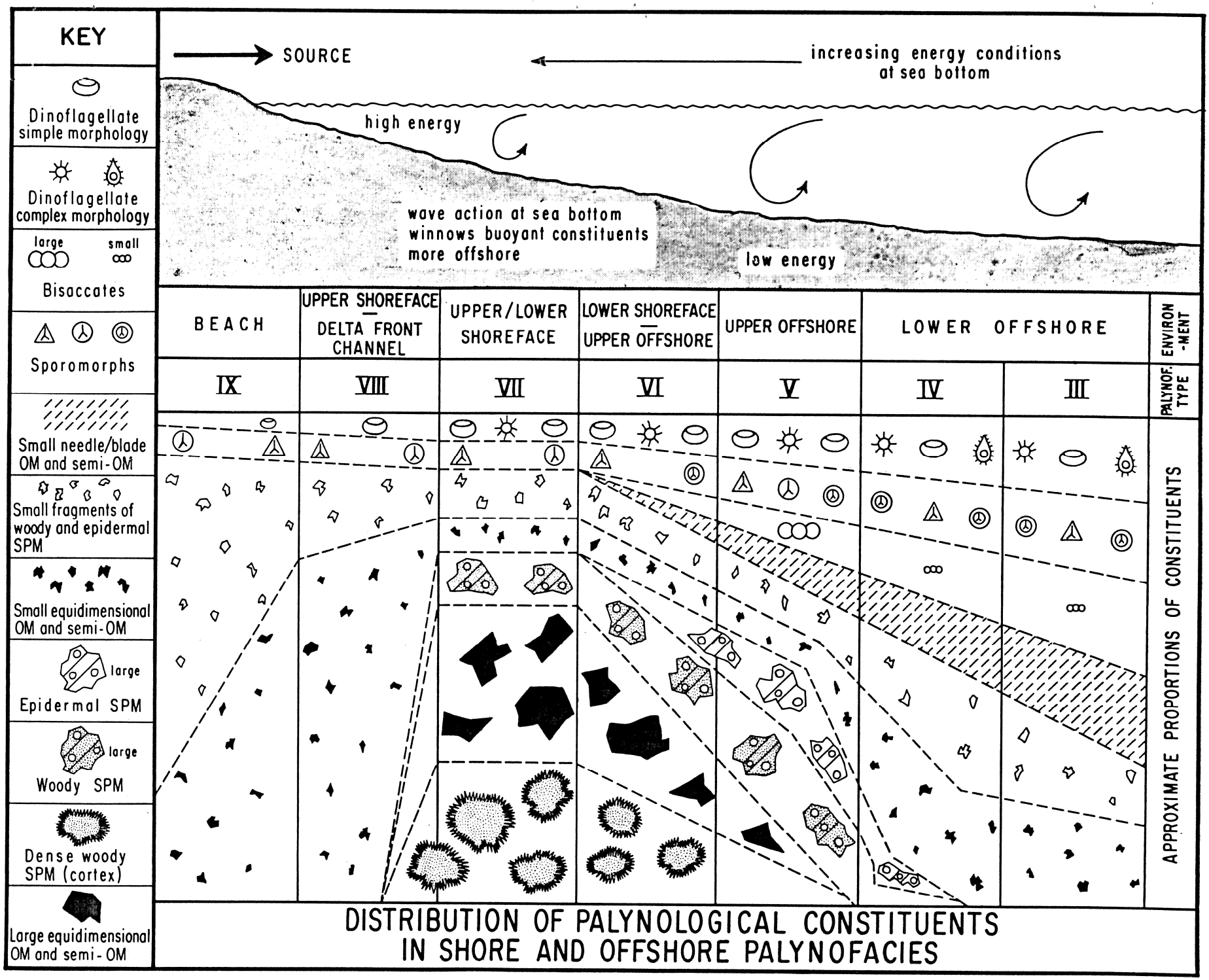

FIGURE 3

REPORT Nº EP53464 DRAWING Nº G.66241/3

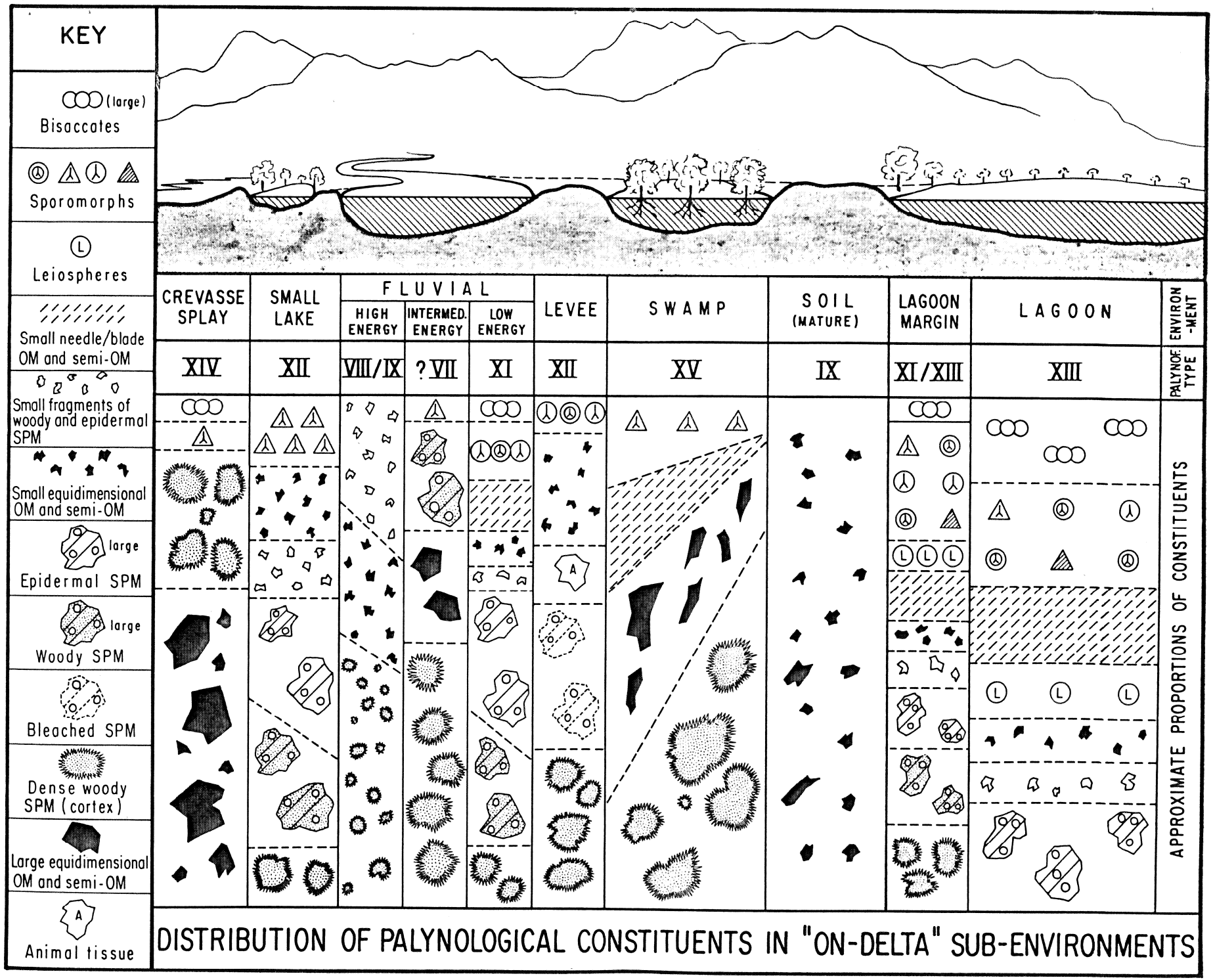

FIGURE 4

REPORT Nº EP53464 DRAWING Nº G.66241/4

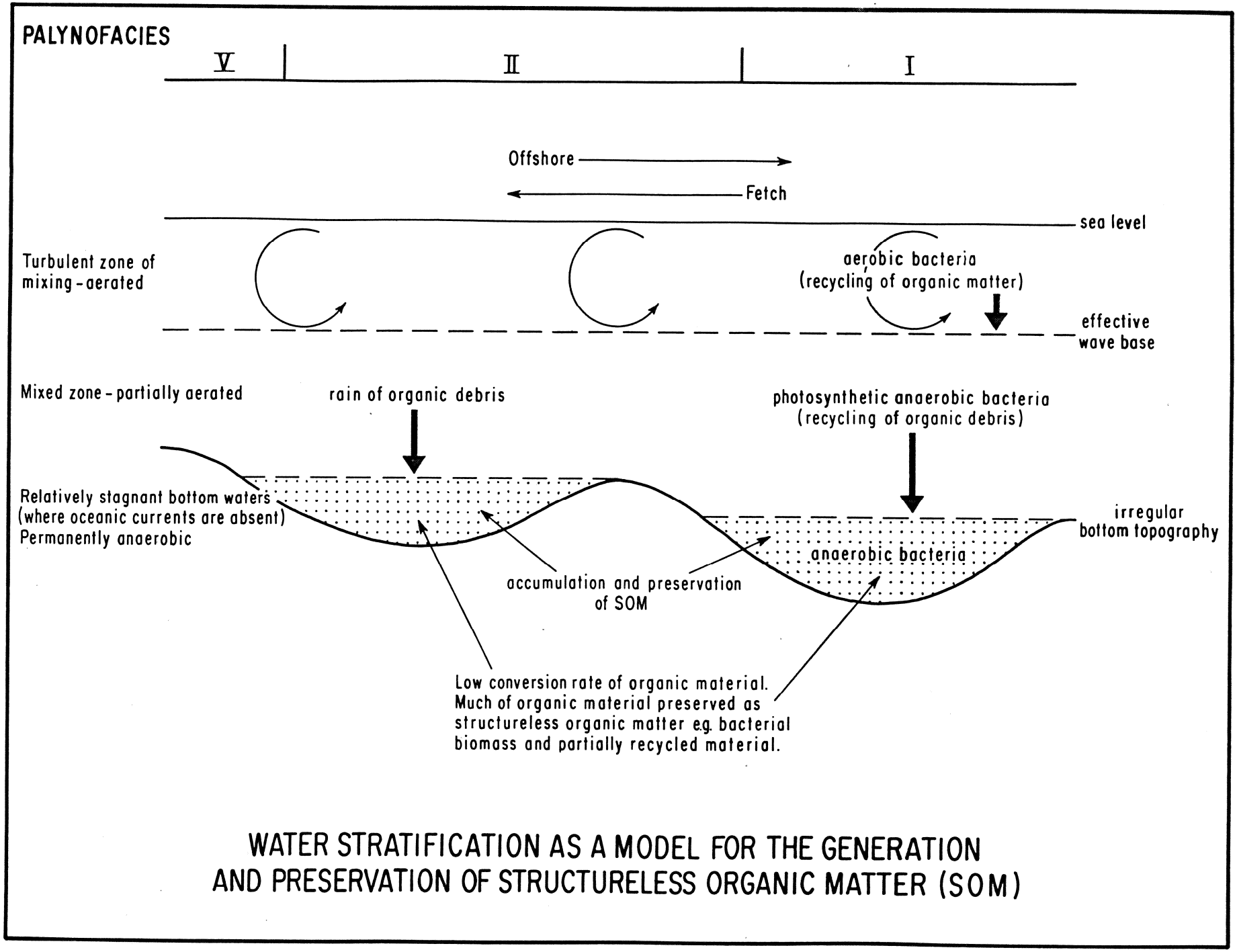

FIGURE 5

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

REPORT Nº EP53464 DRAWING Nº G.66241/5