NSEP-73

A/S NORSKE SHELL

PRODUCTION LICEN

EXPLORATION WELL

NOVEMBER 1979

CONFIDENTIAL

NSEP-73

A/S NORSKE SHELL

PRODUCTION LICENCE 054

BLOCK 31/2

EXPLORATION WELL PROPOSAL 31/2-C

A/S NORSKE SHELL
TANANGER

NOVEMBER 1979

a·s Norske Shell
OLJELETINGS- OG UTVINNINGSAVDELINGEN
(EXPLORATION AND PRODUCTION)

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Deres ref.
Your ref.

Vår ref.
Our ref. EPX/eai

Forus, 15 November 1979

Attention: Jakob Bleie

Dear Sirs,

PRODUCTION LICENCE 054

WELL PROPOSALS 31/2-B & 31/2-C

We have pleasure in sending the two enclosed well proposals for your consideration.

The well 31/2-1 has been suspended without testing either the gas-bearing zone or the interval with oil shows. The well will be tested at the earliest opportunity with better weather in spring 1980.

The attached figure shows positions of the well 31/2-1, the proposed B and C locations and the notional D (deep) location also planned for drilling in 1980, all of which were reviewed in outline at the last meeting of the Technical Sub-Committee.

PROPOSED LOCATION 31/2-B

The proposed 'B' location is a step-out of some 8 km along the crest of the structure. The objectives are:

- to evaluate reservoir parameters along the axis of maximum gross hydrocarbon column.
- to prove maximum hydrocarbon reserves in the major northern fault block.
- to confirm the significance of the seismic flatspot as a direct hydrocarbon indicator.
- to further assess the significance of the oil shows found in 31/2-1.

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- to evaluate the influence of earlier Kimmerian fault movements on reservoir characteristics.

The well should encounter some 140 m of gas bearing reservoir.

PROPOSED LOCATION 31/2-C

The proposed 'C' location is a 4 km step-out down flank from 31/2-1 but in a separate fault compartment. The objectives are:

- to evaluate lateral variation of reservoir parameters eastwards on the flank of the accumulation.
- to test the zone of oil shows seen in 31/2-1 in a better reservoir.
- to test the gas accumulation in a downdip location.
- to evaluate the nature of the flatspot in a location where a very strong amplitude is seen.
- to get a reliable geologic tie to the seismic reflectors above the reservoir for a better regional evaluation.

The well should encounter some 40 m of gas bearing reservoir in a location where the 'flatspot' has high amplitude, as well as penetrating the same depth interval over which oil shows were observed in 31/2-1 in the uppermost, well developed reservoir sands.

DRILLING SEQUENCE

We are actively pursuing the use of two rigs for drilling three locations (B, C & D) and testing 31/2-1 during 1980. The Borgny Dolphin should become available around February 1980 and the second rig (more suitable for drilling through the winter 1980/81) could commence in the February-April period. Consequenctly the 'B' and 'C' locations could well be drilled simultaneously.

Norske Shell proposes to spud the 'C' location first, followed by the other locations as most appropriate at the time.

TECHNICAL SUB-COMMITTEE

We request that partners attend a technical sub-committee meeting on Thursday 22nd November at 10 am in our Forus office with the following agenda:

1. Proposed locations 31/2-B and 31/2-C
2. Drilling sequence

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Statoil, Stavanger EPX/eai 14.11.79

We would hope to gain agreement on a recommendation to the Management Committee who are due to vote on these issues on 29th November 1979, prior to site surveys due to take place during the first half of December.

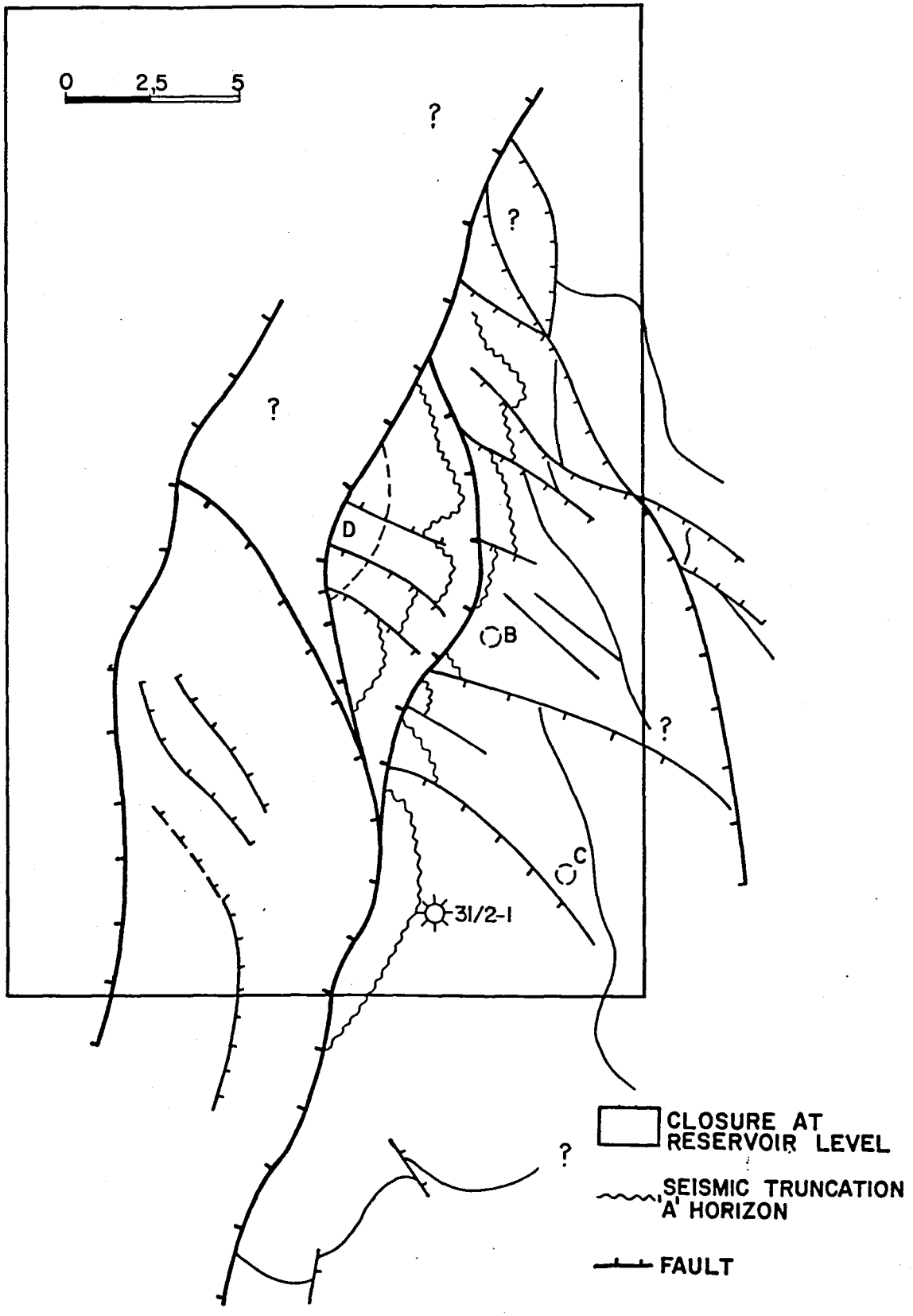
Yours faithfully,

P.B. Watts

P.B. Watts
Exploration Mananger
A/S Norske Shell

Enclosure

BLOCK 31/2 DRILLING PROGRAMME 1980



31/2-C Well Proposal

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4. Panel of Migrated Seismic lines
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APPENDIX I: Drilling Proposal 31/2-c

1. INTRODUCTION

Subsequent to well 31/2-1, it is proposed to drill an exploration well, 31/2-C, in block 31/2 on seismic line 79-416 at sp. 200. The location is in a waterdepth of 328 m and prognosed T.D. is 2600 m.

The co-ordinates are

Lat. 60^{o} 46' 47.1"N
Long. 03^{o} 37' 22.4"E

The well will be drilled 4 km east of 31/2-1 in a downdip location. The gross hydrocarbon column will be less than in 31/2-1, but a conclusive test of the oil shows encountered should be obtained.

The main objectives of the well are to:

- evaluate lateral variation of reservoir parameters eastwards on the flank of the accumulation.
- test the zone of oil shows seen in 31/2-1 in a better reservoir.
- test the gas accumulation in a downdip location.
- evaluate the nature of the flatspot in a location where a very strong amplitude is seen.
- get a reliable geologic tie to the seismic reflectors above the reservoir for a better regional evaluation.

2. CONCESSION SITUATION (Fig. 1)

The concession carries a six well commitment, one of which must reach the Palaeozoic or a maximum of 5000 m. The other five wells must fully penetrate the prospective Jurassic sequence and bottom in Triassic or older sediments. Well 31/2-1 satisfied this requirement, as should well 31/2-C also.

3. GEOLOGICAL SETTING

The prospect is located near the boundary between the Northern Viking Graben and the Horda Platform. It is basically formed by a large NS-trending tilted fault block, heavily broken by younger Jurassic faults in the north, but more gentle in the central and southern part.

Encl. 1 is the well summary sheet for 31/2-1, and in Fig. 2 is shown a preliminary summary of the Jurassic sequence encountered in the well and a schematic environment of deposition curve. This indicates that several cycles within the depositional sequence may have occured.

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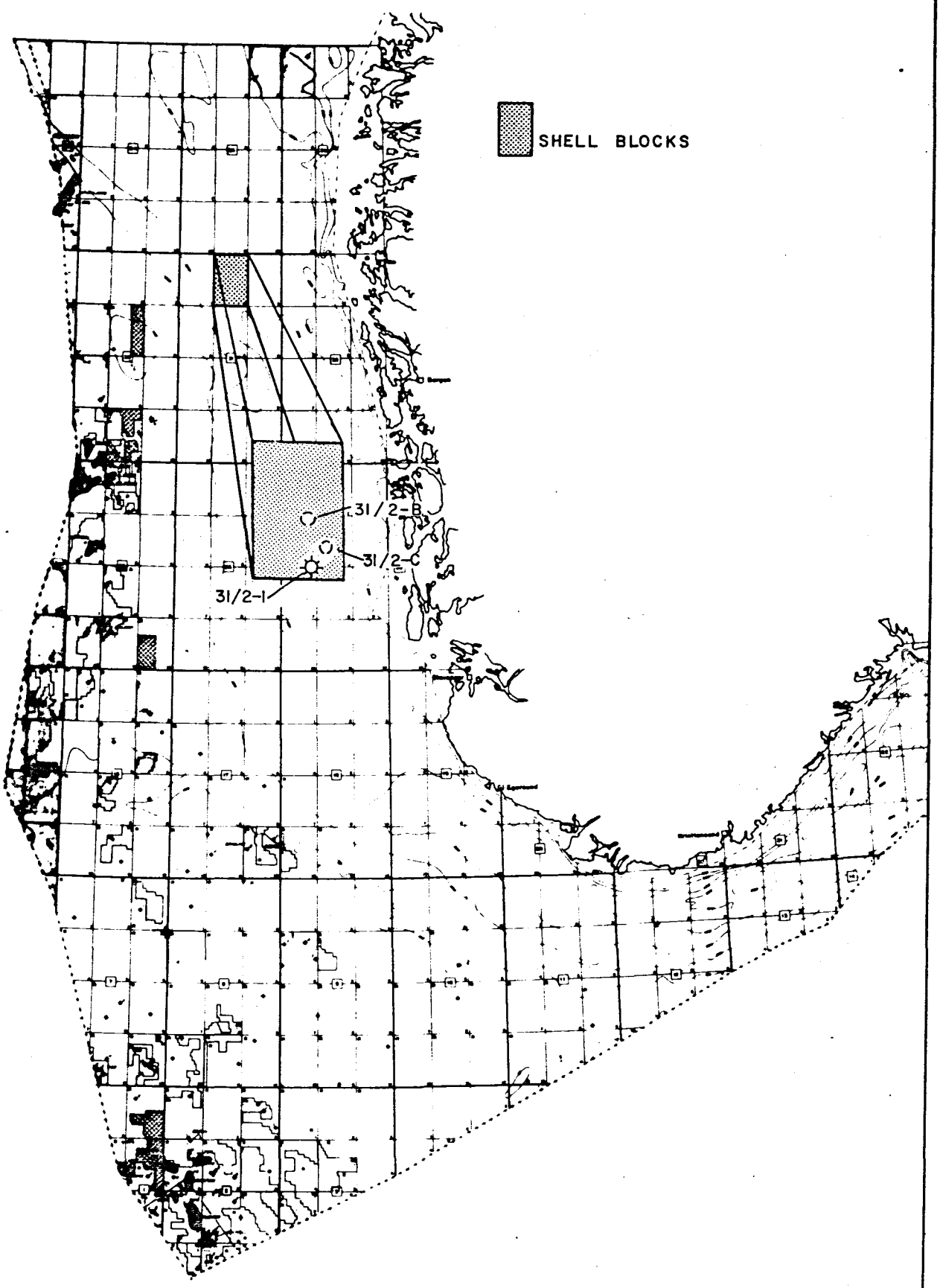

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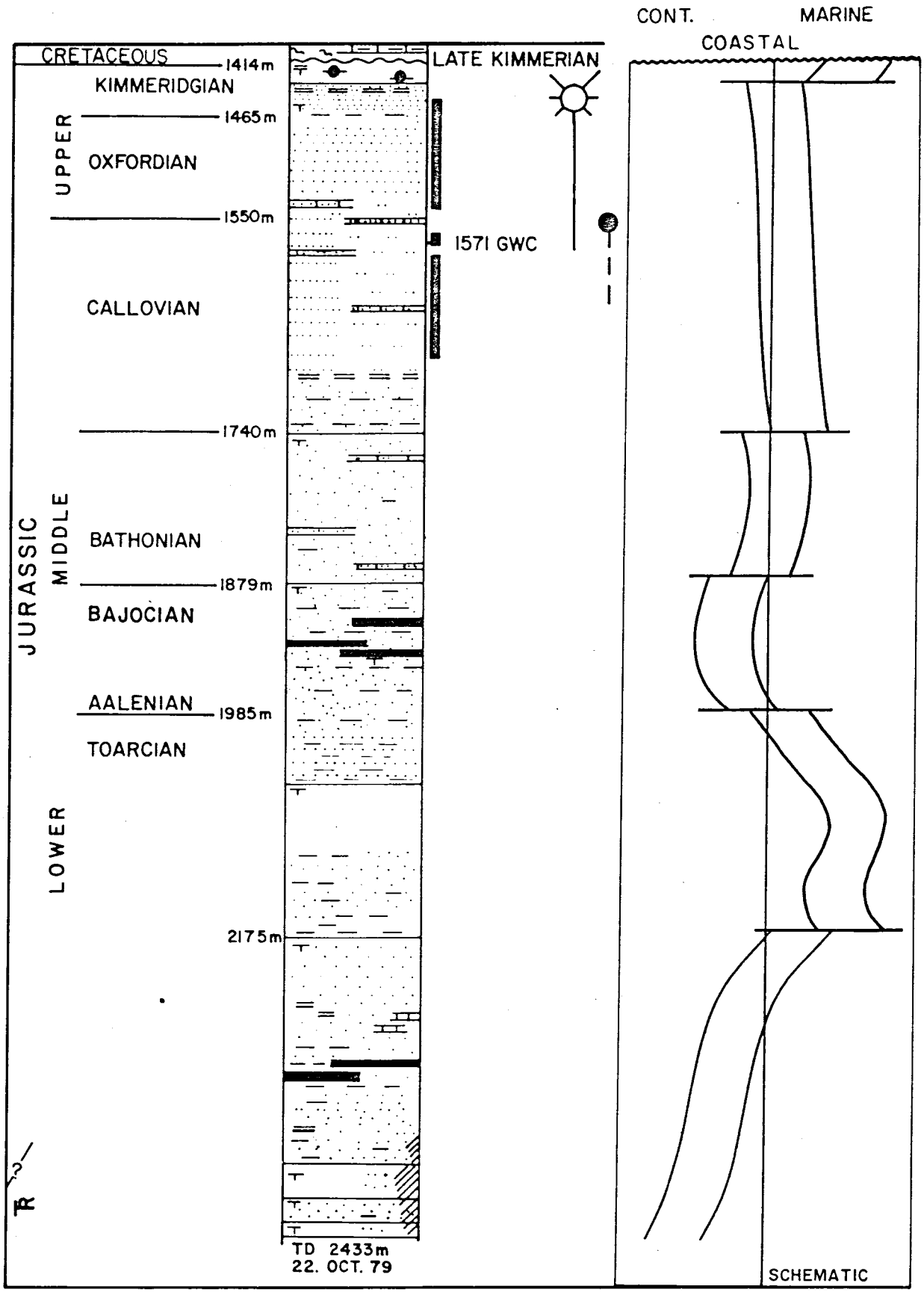
CONCESSION SITUATION
(with FOURTH ROUND AWARD and WELL LOCATION, 31/2-A)

AUTHOR EPXT/I	FIG. 1	DATE NOV. 1979
RPT No. NSEP 73		DRAW. No 553/1



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31/2-1
STRATIGRAPHY OF THE JURASSIC SECTION

AUTHOR EPXT/13 FIG. 2 DATE NOV. 1979
REPORT NO NSEP 73 DRAW. NO 553/2

Encl. 2 illustrates the preliminary log interpretation of the Kimmeridgian to Callovian sand interval that forms the hydrocarbon bearing reservoir in well 31/2-1. The well encountered 132 m of gross gas column and some 50 m of oil shows. The significance of the oil shows is not yet clear.

The Jurassic sandstone sequence is thought to consist of shallow marine to coastal deposits. The upper part of the section consists of a coarse, well sorted but poorly consolidated sandstone, with occasional thin finer and more argillaceous bands. Porosities in this section average over 30% and permeabilities are in the Darcy-range. The sequence fines into the Middle Jurassic and becomes silty and very micaceous near the base of the gas column.

The top of the Bathonian is picked at a massive coastal/marine sandstone which passes into a Middle/Lower Jurassc paralic sequence, thought to be a "Brent equivalent" formation.

The remainder of the Lower Jurassic interval can be divided into "Dunlin" equivalent siltsones, claystones and sands underlain by a massive "Statfjord" sand which in turn rests on Triassic beds.

4. SEISMIC INTERPRETATION

4.1 Seismic Coverage

Block 31/2 is covered by a reasonably dense seismic grid of several different vintages, but at present migrated data is limited to the recently acquired 1979 survey of some 550 km. This survey is orientated in a predominantly NE-SW direction with a line spacing of about 1 km. (Fig. 3).

The quality of the migrated data is good and gives a reliable fault definition over the main structure at the objective levels at 1.5 to 2.0 sec., but in the north the very complex faulting and a regional dip to the NW inhibit the accuracy of the migration. Examples of the data are shown in Encl. 3 and 4. Older unmigrated data has been used to define fault trends outside the new grid and therefore fault intercepts are more uncertain.

4.2 Stratigraphic Identification of Reflections

Preliminary check shot times are available and the stratigraphic tie to the reflection section is shown in Encl. 5.

In the following all depths are measured from RKB and the corresponding seismic times from MSL.

The most important ties are:

- the Base Tertiary, 1392 m ties at 1.516 sec.
- the provisional base Cretaceous, 1414 m ties at 1.534 sec.

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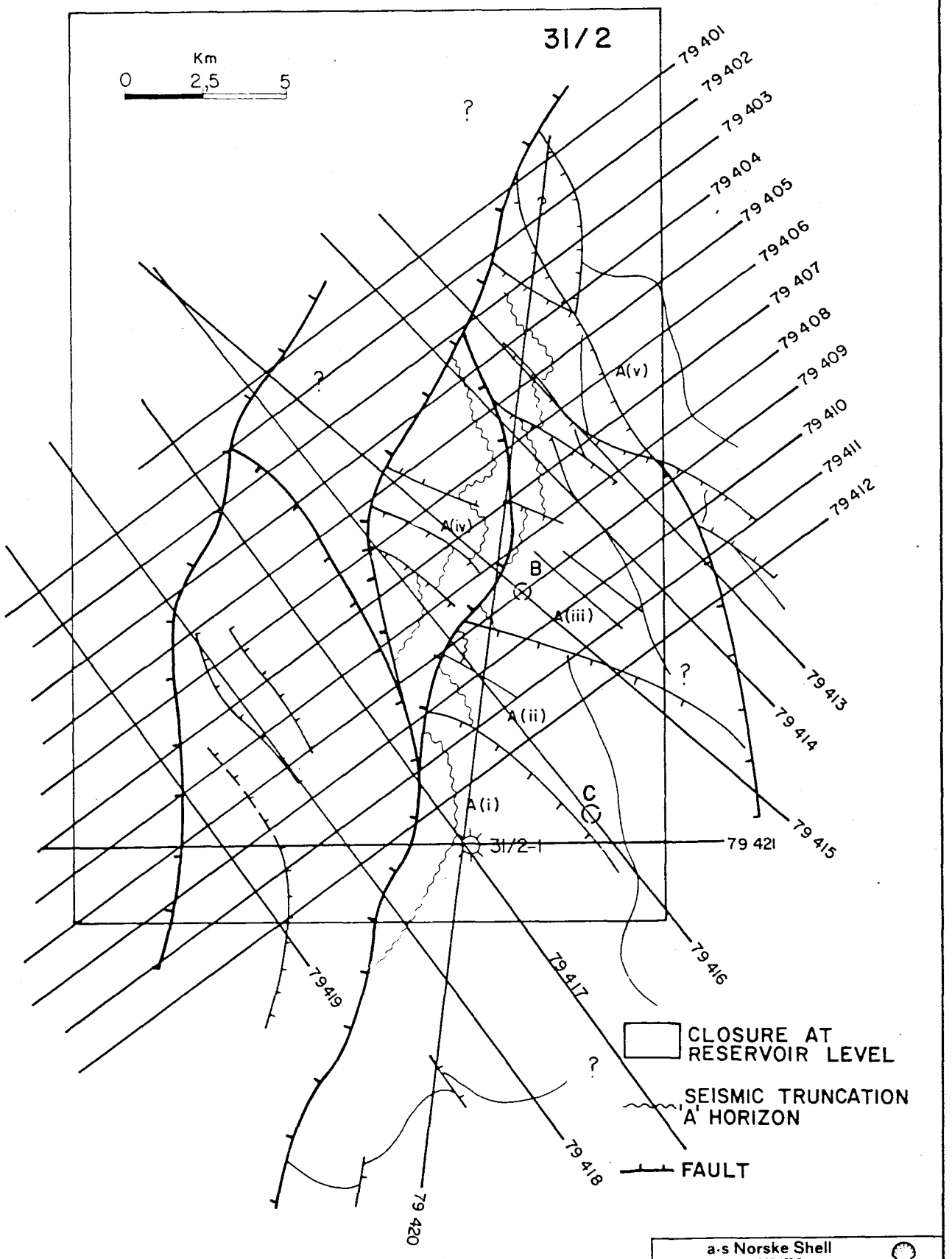

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BLOCK 31/2
1979
SEISMIC PROGRAMME

EPXT/12	FIG. 3	NOV. 1979
NSEP 78		553/3

- the 'A' reflection previously mapped ties with the base of the organic Kimmeridgian shale, 1439 m ties at 1.557 sec.

- The base of the 50% gas saturation, from log interpretation comes at 1571 m and ties at 1.671 sec, while the mappable 'flatspot' at 1.685 sec. ties at 1587 m.

- the 'B' reflection at 1.877 sec corresponds to 1877m and is caused by the onset of the sequence of thin limestones and coals in the Middle Jurassic.

- The 'C' reflection is again generated by a coal sequence at 2290 m corresponding to 2.140 sec.

The provisional top Bathonian appears to be close to 1740m and can be identified locally as a weak seismic reflection at 1.790 sec.

Reliable mappable Top Statfjord and Top Dunlin equivalent reflections have not yet been identified.

Preliminary seismic impedance studies are in progress and show good character correlation between band limited impedance logs and the seismic impedance section. This tie is currently being further revised by log editing and incorporating check shot data.

The coal sequence associated with the 'B' and 'C' reflections are likely to be subject to rapid lateral variations, hence some caution should be exercised when using these reflections to evaluate detailed structure beneath the unconformity.

4.3 Seismic Mapping

Time (isochrone) maps have been constructed at the Top Reservoir and for the 'B' horizon.

The Top Reservoir map (Encl. 6) is derived from maps at the Late Kimmerian unconformity and the 'A' reflector. Little difficulty is encountered in mapping the 'A' reflection in the southern part of the area where it can clearly be identified terminating the flatspot on numerous lines. This provides extra control in addition to normal correlation. The truncation of the 'A' reflection is shown on the map but it is stressed that this seismic truncation merely indicates the limits of seismic resolution. Within the zone of truncation, however, the virtual absence of a Kimmerian unconformity event at some locations possibly indicates the subcrop of the reservoir sands beneath the Palaeocene.

The map shows three main fault trends. In the south a system of basically north-south striking faults stepping down to the west has generated an elongate north-south striking closure. This has been dissected by a secondary NW to SE striking fault system. In the north a third NNE striking system becomes dominant. These main fault trends compare well with previous interpretations of the structure. For convenience individual fault blocks are identified in Fig. 4.

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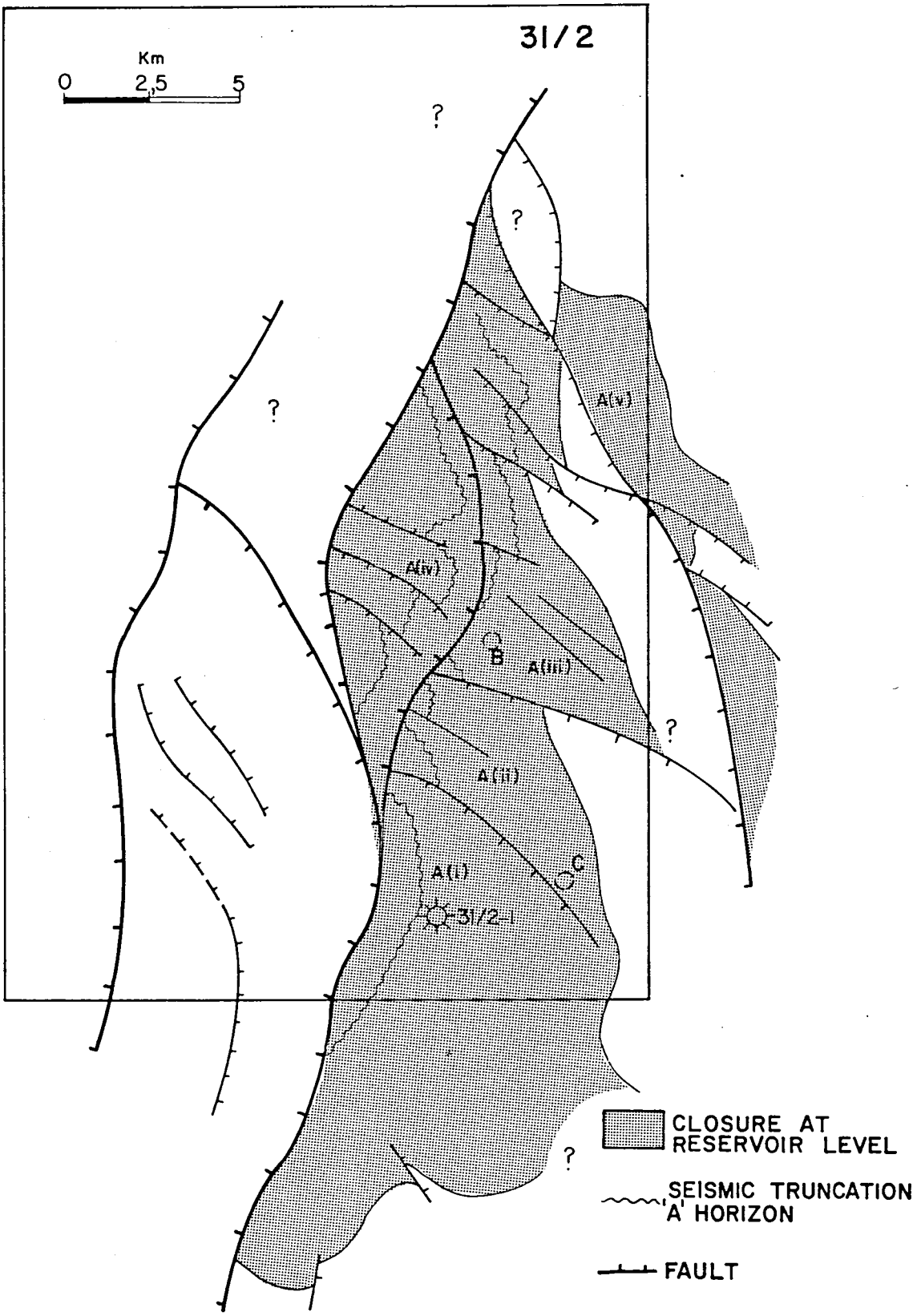

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BLOCK 31/2

KEY TO FAULT BLOCK NOTATION

AUTHOR EPXT/12 FIG. 4 DATE NOV. 1979
REPORT NO. NSEP 73 DRAW. NO. 553/4

Fault definition beneath the Top reservoir is more difficult. The map of the next significant reflector, the 'B' horizon (Encl. 7) shows the same fault pattern, but different fault throws at the A, B and C horizons are clearly seen at several locations. In addition the isopach between the Top reservoir and the 'B' horizon thins both from west to east and south to north, seen on lines 79-421 and 79-420 respectively. These indications of disharmony between the Top reservoir and the 'B' horizon are supported by the geological interpretation of the well results.

The lack of continuous reflections between the Top reservoir and the 'B' horizon make it difficult to predict reservoir distribution without more well control. Also it is not known to what extent these earlier Kimmerian movements have influenced sedimentation.

Well 31/2-1 verified that the seismic flatspot is associated with the base of the gas column. This simplifies depth conversion as it is assumed that under hydrostatic conditions the fluid contact is at constant depth. Average velocity to the top reservoir at the 31/2-1A location is 1818 m/sec. From check shots the flatspot 'ties' to 1562 m.SS giving a velocity of 1854 m/sec to the top reservoir reflection where it truncates the flatspot. A velocity time function has been interpolated between these values. The depth map to Top reservoir is shown in Encl. 8 with the areal extent of the flatspot superimposed on it.

The highest point on the structure occurs in fault block A (iv) on seismic line 79-406, where a gross gas column of some 220 m is anticipated.

Fault block A (iii) is at the southern margin of a large, complex area of closure persisting to the north and eventually merging with the A (v) block.

5. CHOICE OF LOCATION

Well 31/2-1 has demonstrated that, although the seismic flatspot as identifed on a reflection section is a hydrocarbon indicator, its character is very likely to be due to a complex interaction between pore fill, porosity and possibly local changes in lithology and cementation. The natural constraints of the seismic technique further complicate the phenomenon - and hence inhibit its use for early detailed interpretation.

Seismic impedance sections are not yet completed through this well location, but on the reflectivity sections the negative loop (increase in impedance) of the flatspot appears to tie into well 31/2-1 some 15 m beneath the limit of 50% hydrocarbon saturation as interpreted on logs. This could be explained by residual gas saturations, as 10% to 15% hydrocarbon saturations are still encountered at this depth.

Downdip on the eastern side of the prospect the character of the flatspot becomes more strongly pronounced. Currently this is believed to be caused by the intersection of the basal part of the hydrocarbon column with the in part unconsolidated high permeability sands encountered between 1439 m and 1525 m in well 31/2-1.

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A down dip test to evaluate the oil shows is therefore expected to have a higher probability of finding good reservoir development at a location where the flatspot is a strong event. A location in block 31/2 therefore should be on seismic line 79-416 between SP 150 and 210 or on 79-421 between SP 650 and 730. A location on line 79-416 has the added merit of penetrating the A(ii) fault block (figure 4).

Encl.9 shows seismic line 79-416 and a depth section.

To gain adequate information from the gas bearing section of the hydrocarbon column. At least 30 m of gas pay is considered essential.

The seismic flatspot ties at 1562 m in 31/2-1, as the 50% gas saturation is at 1547 m, this implies top reservoir at the C location should be no deeper than 1517 m subsea. Using an interval velocity for the reservoir of 2320 m/sec derived from check shot data the equivalent two way time isopach between top reservoir and flatspot is some 39 m/sec. This further limits the shot point range on line 79-416 from SP 190 to 210.

At shot point 200 two approaches are now made to estimate the gas column. The first is simply a depth conversion to the top reservoir using the techniques used to generate the depth map. Allowing for estimates of the picking errors in times and velocities a gas column of 38 $\pm$ 10 m is expected.

A second approach using solely the time isopach between top reservoir reflection and flatspot suggests a gas sand of 36 $\pm$ 5 m. Errors are based on 50% confidence level.

At this location it is also possible to estimate the extent of the "high quality" reservoir in the oil column. A line parallel to the top reservoir is drawn on the section through the limit of the strong flatspot. The time isopach between this line and the flatspot tie is some 22 msec. Some 25 to 30 m of good reservoir is therefore expected beneath 1562 mSS, giving a total isopach of 40 $\pm$ 5m.

A well location on line 79-416 at SP 200 should therefore:

- encounter 30-45 m of gas column
- encounter any oil shows beneath the gas in some 40 m $\pm$ 5 m of good reservoir
- test the hydrocarbon section in fault block A(ii)
- provide further control for the detailed interpretation of the flatspot reflection where it exhibits a high amplitude
- penetrate some 120 m of 'new' section beneath the Base Tertiary reflection and the top reservoir, allowing conclusive stratigraphic calibration of the 'A' reflector

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31/2-1	SUBSEA DEPTHS IN METRES	31/2-C

1415	TOP RESERVOIR	1509 ± 10	
1501	BASE UNCON. SAND 31/2-1		38 ± 10
1547	BASE 50% GAS SATURATION	1547	
1562	MAPPABLE FLAT SPOT	1562	
	BASE UNCON. SAND 31/2-C	1590-1595	

TABLE ILLUSTRATING 31/2-C PROGNOSIS OVER RESERVOIR INTERVAL

6. PROGNOSIS

(depth in metres SUBSEA)

Seabed	328 m		
Seabed to	1160 m	(± 20m)	Quaternary to Eocene: Clays, claystones, silts + thin sands
1160 m to	1353 m	(± 20m)	Palaeocene: silty claystones with thin sandstones
1353 m to	1402 m	(± 20m)	Cretaceous: marls and claystones, thin argillaceous limestones
1402 m		(± 20m)	LATE KIMMERIAN UNCONFORMITY
1402 m to	1509 m	(± 20m)	Upper Jurassic: organic shale
1509 m		(± 20m)	TOP RESERVOIR
1509 m to	1590 m	(± 10m)	Upper Jurassic: coarse, partly unconsolidated sandstones with finer, argillaceous bands.
1562 m			MAPPABLE SEISMIC FLATSPOT
1590 m -	1905 m	(± 30 m)	Middle Jurassic: Fine silty, micaceous sandstones with thin shales and sandy limestone beds, becoming massive, fine - coarse sandstones with thin sandy limestones
1905 m -	2070 m	(± 30 m)	Middle - Lower Jurassic: Sandstones, shales with coals in the upper section. Shale content increasing downwards
2070 m -	2180 m	(± 30 m)	Lower Jurassic: Silty Claystones with thin sandstones and marls
2180 m -	ca.2400 m	(± 30 m)	Lower Jurassic: Sandstone, fine - coarse with shale bands and coals.
2300 m		(± 40 m)	'C' Reflection
ca.2400 m -	2600m		Triassic: fine sandstones with siltstones and grey/red-brown claystones.

Drilling Proposal 31/2-C

1. WELL — Statoil/Norske Shell/Conoco/Superior Oil/ Norsk Hydro in Production Licence 054.

2. LOCATION — Coordinates: Lat. 60° 46' 47.1"N
Long. 03° 37' 22.4"E

On Seismic line 79-416 at shotpoint 200. Waterdepth approximately 328 m.

3. RIG

4. OBJECTIVES — 1. Upper Jurassic sandstones, proved hydrocarbon bearing in 31/2-1

5. TOTAL DEPTH — 2600 m subsea in Triassic

6. PROGNOSIS — (depth in metres SUBSEA)

Seabed	328 m		
Seabed to	1160 m	(± 20m)	Quaternary to Eocene: Clays, claystones, silts + thin sands
1160 m to	1353 m	(± 20m)	Palaeocene: silty claystones with thin sandstones
1353 m to	1402 m	(± 20m)	Cretaceous: marls and claystones, thin argillaceous limestones
1402 m		(± 20m)	LATE KIMMERIAN UNCONFORMITY
1402 m to	1509 m	(± 20m)	Upper Jurassic: organic shale
1509m		(± 20m)	TOP RESERVOIR
1509 m to	1590 m	(± 10m)	Upper Jurassic: coarse, partly unconsolidated sandstones with finer, argillaceous bands.
1562 m			MAPPABLE SEISMIC FLATSPOT
1590 m - 1905 m		(± 30 m)	Middle Jurassic: Fine silty, micaceous sandstones with thin shales and sandy limestone beds, becoming massive, fine - coarse sandstones with thin sandy limestones

1905 m - 2070 m	(± 30 m)	Middle - Lower Jurassic: Sandstones, shales with coals in the upper section. Shale content increasing downwards
2070 m - 2180 m	(± 30 m)	Lower Jurassic: Silty Claystones with thin sandstones and marls
2180 m - ca.2400 m	(± 30 m)	Lower Jurassic: Sandstone, fine - coarse with shale bands and coals.
2300 m	(± 40 m)	'C' Reflection
ca.2400 m - 2600m		Triassic: fine sandstones with siltstones and grey/red-brown claystones.

7. CUTTING SAMPLES

Ditch cuttings to be collected every 10 m below 30" casing, and every 3 m below 1130 m. Mud logging will be carried out by a contractor.

8. CORING

For a detailed evaluation of the well the coring objectives are two-fold:

i) Upper/Middle Jurassic reservoir section
Interval 1509 - ca.1600 m

Coring to commence in Upper Jurassic Shales immediatly below the Late Kimmerian Unconformity and to continue to at least 30 m below the hydrocarbon-water contact.

ii) 'Statfjord' reservoir
Interval 2180 - ? m

At least one 20 m core to be taken on good cuttings indications of reservoir development regardless of shows. If the reservoir is hydrocarbon bearing, coring to continue until at least one core is taken in the water zone.

9. CASING PROGRAMME

To be specified in final drilling programme

10. LOGGING PROGRAMME

at 20" casing depth GR/ISF/SONIC/SP
FDC/CNL/GR/CAL
LSS

at 13 3/8" casing depth	GR/ISF/SONIC/SP FDC/CNL/GR/CAL LSS SWS
at 9 5/8" casing depth	GR/ISF/SONIC/SP FDC/CNL/GR/CAL LSS MSFL/DLL/CAL/SP/GR SWS HDT CBL (on 13 3/8" and 9 5/8" casing)
at T.D.	GR/ISF/SONIC/SP FDC/CNL/GR/CAL LSS MSFL/DLL/CAL HDT SWS CBL (on 7" Liner if required) Velocity Survey

11. TESTING PROGRAMME

RFT's and/or production tests as required.