BP PETROLEUM DEVELOPMENT LTD., NORWAY (U/A)

29/6-a Drilling Proposal

by

D.G. Dalton and R.W. Ward

29/6-a/W20

Stavanger

September, 1981

Approved by:

C.C. Bailey

A.M. Spencer

BP Petroleum Development Ltd., Norway
(Utenlandsk aksjeselskap)

SØRFLÅTVEIEN 11, P.O.BOX No.3077 MARIERO, 4001 STAVANGER

BP Petroleum Development (Overseas) Ltd.
Britannic House
Moor Lane
London EC2Y 9BU
ENGLAND

Attention: Mr. L.P. Newman/Dr. S.F. Schuyleman

Our reference	Your reference	Telephone (04) 589580 Telex 33339 BPEXPN	Date
BGW/asc-99/81 626/1/043			9 September 1981

Dear Sirs,

DRILLING PROPOSAL: WELL NO. 1, BLOCK 29/6, LICENCE 043, NOCS

The above well is the final commitment well for licence 043, to be completed by 1st September 1982.

The well is to be drilled using the Sedco 707 semi-submersible, currently drilling on BP block 23/26 UKCS, due in Norwegian waters in late October.

The selection of a location in fault-block A was agreed in principle at the Work Programme and Budget discussions in Stavanger in May, and a site survey was carried out in June over a certain area of this fault-block within which a detailed location could be chosen at a later date, following interpretation of the most recent seismic data.

The position with Statoil, 50% partners in the acreage, is that they are examining our recommendation for drilling on line 21 SP.302, put to them in a technical meeting on 7th September, and will revert shortly.

The drilling programme is being submitted to the NPD today and we hope that they will not delay granting permission to drill the well at the recommended location.

All this is of course subject to confirmation from London of the verbal approval obtained during your August visit to BP Stavanger when a technical discussion was held on licence 043.

With regard to the drilling proposal I would like to comment on the geological model.

..../2

The fault-pattern presented across the B structure is oversimplified as Ward and Dalton point out in the drilling proposal. Data quality is not good, and only the main block-bounding faults can be followed across the area with any degree of confidence. The fault-pattern is more complex than depicted in the current interpretation - for example there may be several sets of cross-faults present. However resolution of the detailed fault-pattern will have to await results of the 3-D seismic survey now under way.

The stratigraphic model invokes the presence of an unconformity between the Brent and Heather Formations, beneath which in some fault-blocks the Brent reservoir can be partially or even completely eroded, eg. 3/15-2 and 30/7-7. In the β structure there is, in my opinion, no evidence for this unconformity, certainly not in wells 30/7-6 and 30/7-8, and neither in well 30/4-2, where in the report 15 m is postulated to have been eroded off the top of the Brent Formation. In the β structure, the well-evidence suggests that the earliest Jurassic phase of faulting was post Heather/pre-Kimmeridge Shale. Subsequent erosion over differentially uplifted fault-blocks led to thickness variations in the Heather shales, but, fortunately, erosion nowhere appears to have been deep enough to erode any part of the Brent, and it is therefore reasonable to hope that the Brent will be fully represented throughout fault-block A, even in the highest structure position.

In conclusion, we would be grateful if you could formally approve the recommended location as soon as possible so that we can finalise our plans with Statoil and the NPD.

Yours faithfully,

Brian Williams

B.G. Williams
Exploration Manager

CONTENTS

FIGURES

TABLES

ENCLOSURES

1. INTRODUCTION

Licence 043 comprises blocks 29/6 and 30/4 which lie in the Viking Graben close to the UKCS - NOCS Median line (Fig. 1). It is a third round licence awarded to BP (50%) (operator) and Statoil (50%) (carried) in August 1976 with initial expiry on 1st September 1982. The commitment was three wells to be completed by 1st September 1980 but in July 1980 the partners were granted a two year postponement. To date, two of the commitment wells have been completed leaving one more well to be drilled by 1st September, 1982. At that time the partners will have to relinquish 50% of the licence.

Drilling results directly relevant to licence 043 are as follows. BP well 30/4-1 was drilled in 1979 to test a deep Jurassic fault block within the Viking Graben and encountered water wet Brent Formation (Drake 1979). Our second commitment well, 30/4-2, was drilled in 1980 in the SW corner of the licence, on a structure which had already been proven to contain hydrocarbons by Norsk Hydro's well 30/7-6. 30/4-2 confirmed the existence of gas condensate in the Brent Formation in the structure (Dalton 1980). This structure, known as the β structure, is a complex series of Jurassic fault blocks extending into NOCS block 30/7 to the south. Wells 30/7-6 and 30/4-2 both appear to lie on the same fault block. Most recently, Norsk Hydro have drilled 30/7-8 on a different fault block on the same, overall β structure and have again encountered gas and condensate in the Brent Fm.

A 3D seismic survey across the β prospect will be conducted during Autumn 1981 in conjunction with NOCS licencees 040 (29/9, 30/7) and UKCS licencees P 090 and P118. Results will be available in early 1982.

This report proposes the drilling of the final licence 043 commitment well, to evaluate a separate fault-block on the β prospect gas condensate discovery. The drilling location must be chosen now, in advance of the results of the 3D seismic work because of the necessity to use a 15 000 psi rig and the availibility of such a rig to BP Norway (Sedco 707). Thus the location proposed here (29/6-a) has been chosen on the basis of current mapping of the existing poor quality 2D seismic data. The main element in the detailed choice of location on the β prospect has been as mentioned above, the decision to drill in a different fault block from the two fault blocks tested by the existing three wells.

2. STRUCTURAL INTERPRETATION

2.1 Regional Structure

The β prospect is a structurally complex area in the SW corner of licence 043. At Base Cretaceous level (Fig. 1) it is seen as a high nose protruding into the Viking Graben at the intersection of two high trends:

i) The Brent High, trends NNW-SSE through UKCS blocks 3/9 and 3/15 into NOCS 29/6, and is similar to the parallel Hutton - Ninian - Alwyn trend further west. These highs comprise Jurassic faulted escarpments with westerly dipping dip slopes terminated at large growth faults throwing to the east. There is considerable thinning onto these ridges due to successive erosion in the Middle and Upper Jurassic, in conjunction with growth faulting.

ii) The Fetlar ridge trending NNE-SSW is an old horst feature and where drilled in UKCS 3/25 showed Upper Jurassic sediments resting on Devonian. This ridge plunges to the NNE towards 29/6. It is mapped on the β structure as a collapsed anticline in the Jurassic, evident also at base Cretaceous. East of this axis are easterly dipping fault blocks, whilst immediately to its west they dip westwards.

A series of major faults downthrown to the east mark the edge of the Viking Graben.

2.2 Seismic Interpretation

a) Seismic Data

There is considerable control from several seismic surveys across the β prospect, as demonstrated by the shotpoint density on any of the maps (Encl. 2 - 4). However the Jurassic dip is sufficiently steep and faults closely spaced that it is not possible to resolve on unmigrated data where seismic events belong. Mapping down to the Red Horizon (base Cretaceous) can be carried out using unmigrated lines (all seismic data shown on the map) and the contours are then migrated. The Violet Horizon (Top Statfjord Fm) has been mapped using only migrated dip lines, available from only two surveys: Total's 1978 survey (802-lines) and BP's 1980 survey (BP-80 lines). An example from the BP survey is shown on Encl. 1.

b) Seismic Mapping

Maps on two seismic horizons, Red and Violet, are included with this report (Encl. 2, 3).

The Red Horizon is a fairly strong event with good continuity except for an area of very poor data quality near 30/4-2 and 30/7-6; probably caused by gas dispersed through the Cretaceous. The area corresponds closely to closure as mapped at base Tertiary. Mapping of the Blue Horizon within the Lower Cretaceous clearly shows a velocity anomaly associated with this poor data area.

Data quality below the Red horizon is very poor and the Violet horizon is a phantom event from dip indications over much of the mapped area with little evidence for the throw of faults. There is some improvement of data quality near the proposed well location. The fault immediately west is clearly seen on the example section (Encl. 1) with the throw given by character correlation. Elsewhere fault definition is vague and the fault pattern is derived from the effect at the Red Horizon. The map presented is much simplified and apparent minor faults and cross faults are omitted both for clarity and because the strikes of the faults could not be determined.

Violet is the only horizon mapped directly from the seismic data since any reflection associated with the Brent Fm is confused with multiples near the Red horizon. Maps of top and base Brent have therefore been derived by form mapping.

2.3 The Middle and Upper Jurassic Sequence

The purpose of this section is to summarise the stratigraphy of the Upper and Middle Jurassic sequence in nearby wells in order to establish the criteria for the construction of the top Brent Formation form map. This sequence is as follows:

Red Horizon (base Cretaceous)

KIMMERIDGE CLAY FM.
HEATHER FM.
BRENT FM.
DUNLIN FM.

Violet Horizon (top Statfjord)

Data from nearby wells indicate that there are two main unconformities within this sequence. Where observed in the wells these unconformities lie:

i) between Heather Formation mudstones and Brent Formation sandstone and

ii) between Kimmeridge Clay Formation and Heather Formation mudstones.

(a) The Dunlin Formation lies conformably on the Statfjord Formation and was completely penetrated in NOCS 30/4-2 on the structure and in UKCS 3/15-2 and 3/15-4. In these wells it shows a thickness of between 246 m in 3/15-2 and 277 m in 30/4-2 representing a slight E to W thinning. The Jurassic faults comprising the β structure do not appear to affect the thickness of the Dunlin Formation (unlike the main easterly throwing faults of the Ninian and Brent Trends). Minor thickness variations may occur as a result of the deposition of the overlying Brent Formation. The formation is predicted to have a thickness of approximately 280 m over the β structure.

(b) The Brent Formation is the main reservoir horizon in the area. It was penetrated in NOCS wells 30/4-2 and 30/7-6 on the structure, and nearby, in NOCS well 30/4-1 and UKCS wells 3/15-1, 3/15-2 and 3/15-4. In all these wells the Brent Formation can be divided into the five members

CORRELATION OF KIMMERIDGE CLAY FM, HEATHER FM AND BRENT FM IN UKCS BLOCK 3/15 AND NOCS BLOCKS 30/4 AND 30/7

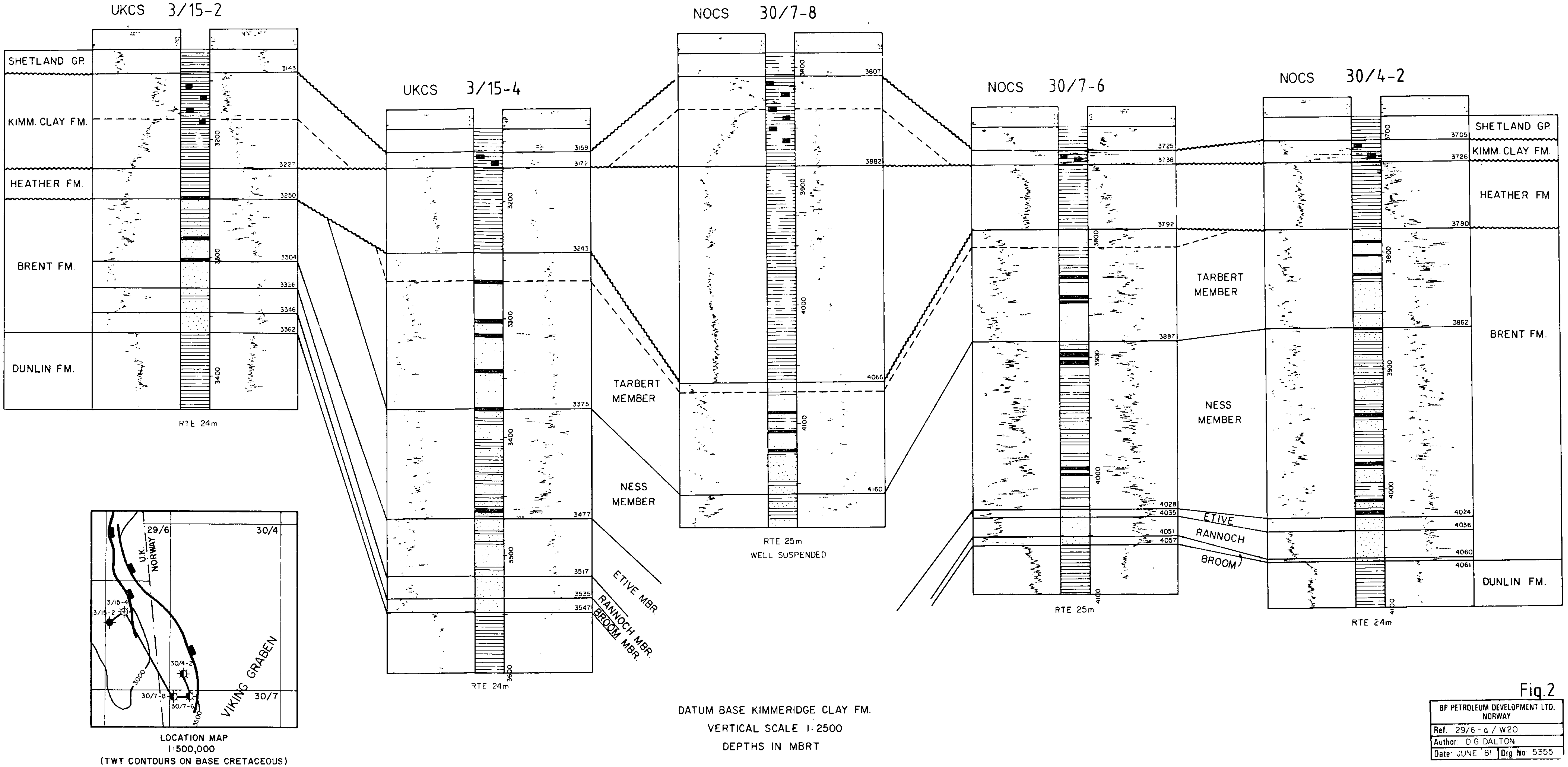


Fig.2

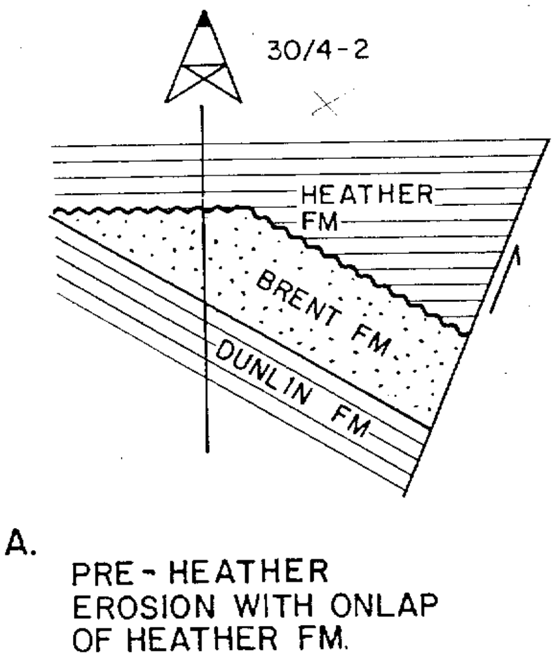
BP PETROLEUM DEVELOPMENT LTD. NORWAY	
Ref. 29/6 - a / W20	
Author: D G DALTON	
Date: JUNE '81	Drg No 5355

defined by Deegan and Scull (1977) - the Tarbert, Ness, Etive, Rannoch and Broom Members (Fig. 2).

The contact with the underlying Dunlin Formation is approximately conformable although the common occurrence of a basal lag in the lowermost Broom Member suggests minor erosion due to scouring.

The upper contact is more complex and in several of the wells it appears to be an unconformity. Detailed log correlation within the Tarbert Member is possible between wells 30/4-2, 30/7-6 and 30/7-8. (Fig. 2) It is apparent from this that the top 15 m of the Tarbert Member is missing in 30/4-2 relative to both 30/7-6 and 30/7-8. To the west in UKCS 3/15-2 the whole of the Tarbert Member is missing and the Heather formation is underlain by the Ness Member.

It is thought that the absence of section at the top of the Brent Formation in 30/4-2 is due to erosion. However it is not clear whether the unconformity surface follows the top Brent Formation downdip and is overlain by onlapping Heather Formation (Fig. 3 - A) or whether it is due to intra-Heather Formation erosion (Fig. 3 - B).



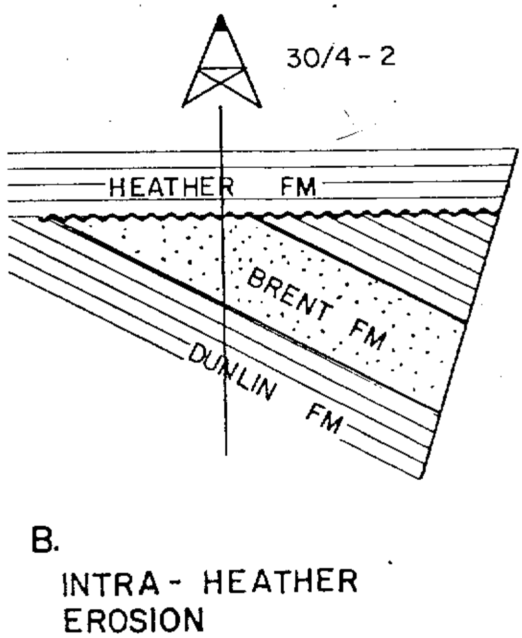
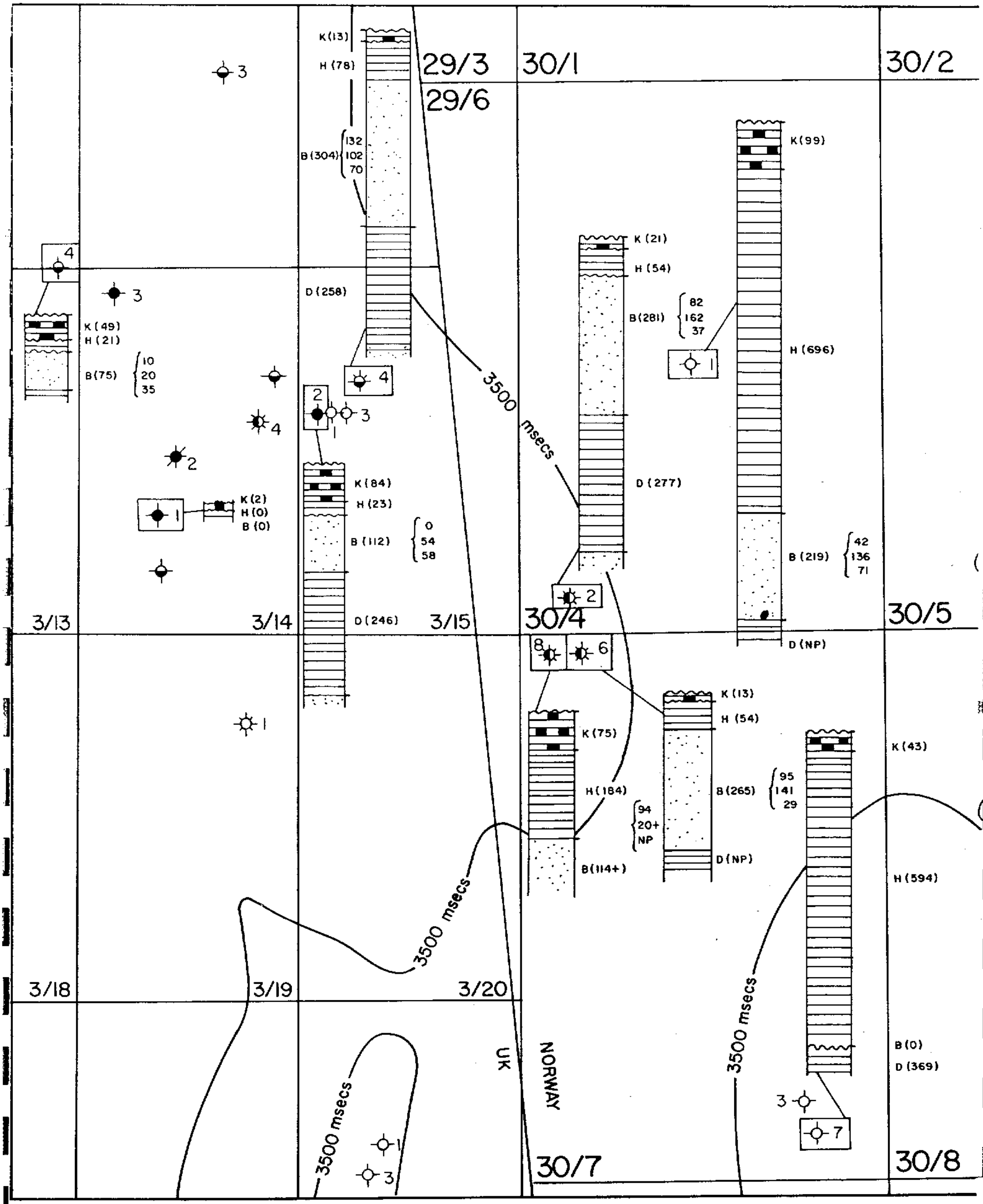


Fig. 3 Two possible models for Brent-Heather Fm. Relationship.



SUMMARY OF JURASSIC SECTIONS IN WELLS CLOSE TO LICENCE 043

SCALE OF MAP 1 : 250,000
SCALE OF SECTIONS 1 : 10,000
FIGURES IN BRACKETS ARE FORMATION THICKNESSES IN METRES.

K KIMMERIDGE CLAY FM
H HEATHER FORMATION
B BRENT FORMATION
D DUNLIN FORMATION
NP NOT PENETRATED

{ TARBERT MBR
NESS MBR
ETIVE, RANN.+ BROOM MBRS

Fig. 4

BP PETROLEUM DEVELOPMENT L[illegible] NORWAY
Ref: 29/6a – W20
Author: D.G. DALTON

The present thickness of the Brent formation over the β structure is primarily a function of whether erosion has occurred because the depositional thickness is fairly uniform (265 m in 30/7-6 and pre-erosion thickness 296 m in 30/4-2). On the eastern fault segments of the structure, where there is well control, top Brent erosion is not very significant. Further west, towards the anticlinal axis, it is likely to have undergone considerable erosion and may have been removed entirely on the anticlinal axis.

(c) The Heather Formation seems to lie unconformably above the Brent Formation. The dipmeter in 30/4-2 shows a change in dip direction from NW in the Heather Formation to predominantly SE in the Brent and Dunlin Formations.

The thickness of the Heather Formation varies from 23 m in UKCS 3/15-2 to 184 m in NOCS 30/7-8 and in the graben (where syndepositional faulting has occurred) it attains a thickness of 696 m (NOCS 30/4-1). The thickness variation on the β structure and in the UKCS 3/15 wells is difficult to explain.

Thin sequences of Heather Formation do not necessarily correspond with eroded Brent sequences, as might have been expected. For example, 30/4-2 and 30/7-6 have the same thickness of Heather Formation despite 30/4-2 having an eroded Brent sequence. In addition, thin sequences of Heather Formation do not correspond with thin overlying Kimmeridge Clay Formations - 3/15-2 has a thick Kimmeridge Clay sequence and a relatively thin Heather Formation. (Fig. 4).

Two possible explanations for those thickness variations are: syndepositional faulting giving rise to thick sections in the downdip and downthrown parts of the fault blocks; or alternatively, erosion at the upper boundary of the formation, following an episode of faulting.

(d) The Kimmeridge Clay Formation lies above the Heather Formation and when fully developed in this area is characterised, on the gamma log, by a gradual uphole increase in API followed by the normal, very high API 'hot shale' response (e.g. 3/15-2 and 30/7-8 Fig. 2). However in 30/7-6 and 30/4-2 the Kimmeridge Clay Formation is thin and consists only of the upper, very high API, unit. This suggests that in some locations a period of non deposition or erosion followed the deposition of the Heather formation. The scant palaeontological data available also supports the existence of this hiatus. In both 30/4-2 and 30/7-6 the Heather Formation (dated as Callovian or Early Oxfordian) is overlain by the Kimmeridge Clay Formation of Portlandian and mid to late Volgian age respectively. In neither well was there any evidence for rocks of Kimmeridgian age.

The Kimmeridge Clay Formation was deposited during a sea level high stand, making it less likely that the hiatus was due to erosion. Also, fault blocks with thin deeply eroded Jurassic sequences invariably still have a cap of high API Kimmeridge Clay Formation. For example well 3/14-1 on the Alwyn Field has 2 m of Kimmeridge Clay Formation lying on the Dunlin Formation. This demonstrates that the Kimmeridge Clay Formation onlaps the fault blocks and suggests that the hiatus at the base of the formation may be due to non deposition.

The Kimmeridge Clay Formation varies in thickness from 13 m in 30/7-6 to 84 m in 3/15-2. The top of the formation is the 'Base Cretaceous' unconformity which is correlated with the Red Horizon.

(e) Suggested Geological History of the Structure

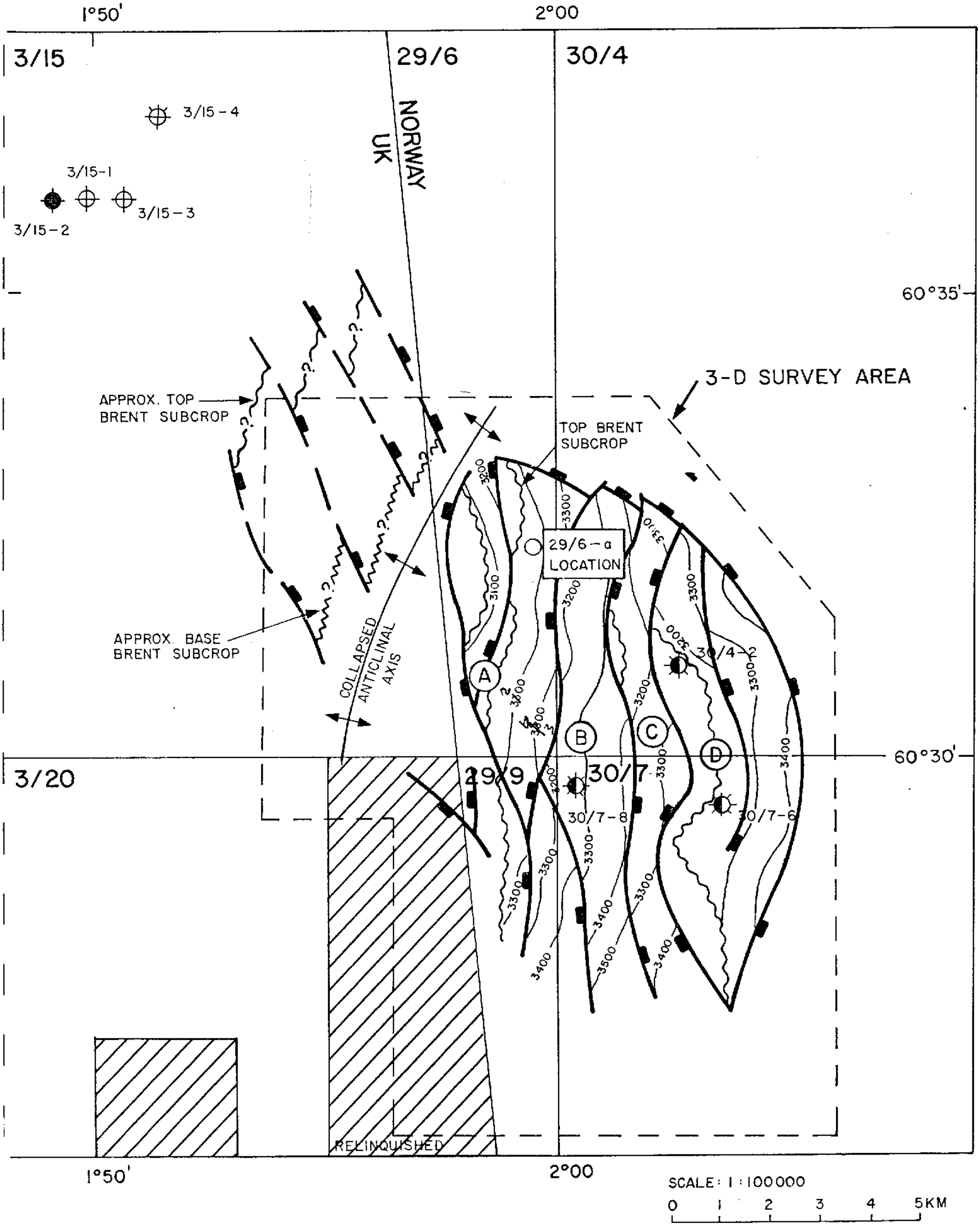
The Dunlin and Brent Formations conformably overlie the Statfjord Formation and are predicted to have a combined depositional thickness of approximately 540 m over the β structure. The deposition of these formations was not significantly affected by the faulting on the β structure.

During late Jurassic times the history of the structure was more complex, and movement on the fault segments comprising the structure affected the deposition of both the Heather and Kimmeridge Clay Formations.

Soon after the Brent Formation was deposited faulting and erosion occurred such that the Brent Formation was eroded on some of the fault blocks. It is likely that this erosion was deepest near the anticlinal axis to the west of licence 043. Before fault movement had ceased the Heather Formation was deposited, possibly resulting in a thickening of the sequence on the downthrown side of the faults. The Kimmeridge Clay Formation was then deposited during a sea level high stand and onlapped the fault blocks such that the highest blocks were capped by a thin, condensed sequence.

2.4 Construction Top Brent Formation Form Map (Encl. 4)

The top Brent Fm map was constructed from the Violet and Red maps. The Dunlin Fm and Brent Fm (prior to erosion) were assumed to be locally of constant thickness and so 400 ms was subtracted from the Violet horizon to give the top Brent surface. This figure includes seismic lag from top Statfjord to Violet. Vertical time was used rather than the stratigraphic thickness but errors due to change of dip are minimal compared with other assumptions. The surface derived was terminated updip assuming a Brent-Heather unconformity 60 ms below the base Cretaceous (Fig. 3B), slightly greater than the seismic lag to the Red Horizon. This value, based on the thickness of the Upper Jurassic in 30/4-2, where the top Brent Fm is slightly eroded, was arbitrarily applied to all fault segments. As discussed in the previous chapter the Upper Jurassic sequence may vary considerably in thickness but there is no sure method of allowing for this, and so the single, unvarying value of 60 ms has been employed for the sake of simplicity.



SKETCH MAP OF β STRUCTURE

(Time contours in TWT msecs on the Top Brent Fm form map.)

Fig.5

BP PETROLEUM DEVELOPMENT LTD. NORWAY	
Ref: 29/6-a/W 20	
Author: D.G.DALTON/R.W.WARD	
Date: AUGUST 81	Drg No: 5609

3. TRAP

3.1 Structure and Trapping Mechanism

Over the β structure, the Tertiary and Cretaceous horizons define low relief domal structures on top of a Base Cretaceous nose which plunges down into the graben towards the SE. Beneath the Base Cretaceous, the Jurassic structure has the form of a collapsed anticline composed of N-S orientated fault segments. The axis of the anticline is orientated NE - SW and lies close to the western boundary of licence 043. The fault segments mapped in blocks 30/4 and 29/6 represent the eastern limb of the anticline.

In licence 043 on the β structure four main fault segments can be defined to the W of the main graben fault. The Violet Horizon which defines these four fault segments dips to the east but is downthrown to the west. The fault segments have been labelled from west to east - A, B, C and D (Fig. 5 and 6). 30/7-8 was located on the B segment and 30/4-2 and 30/7-6 were located on the D segment. Fault segments D and B were proven to contain gas condensate in the Brent Formation by the above wells. However, the GWC was much deeper in fault Segment B (4084 mss in 30/7-8) than in fault segment D (3846 mss in 30/4-2).

Pressure data from the Brent Formation in these two fault segments indicate that the aquifer gradient in the three wells is on the same trend and thus within the same pressure regime (Fig. 7). Thus it is likely that the Brent Formation aquifer is in communication across fault segments B, C and D. The Brent Formation hydrocarbon accumulation in fault segments B and D must have separate spill points, defined by separate closures against the bounding faults. It is likely that fault segment C also contains hydrocarbons in the Brent Formation and has the same spill point as segment D.

Defining a Brent Formation trap in fault segment A is more difficult. Doubts about the thickness of the Upper Jurassic interval produce three possibilities:

a) the Base Brent Formation subcrops beneath the Heather Formation producing a subcrop trap.

GEOLOGICAL DEPTH SECTION ACROSS β STRUCTURE

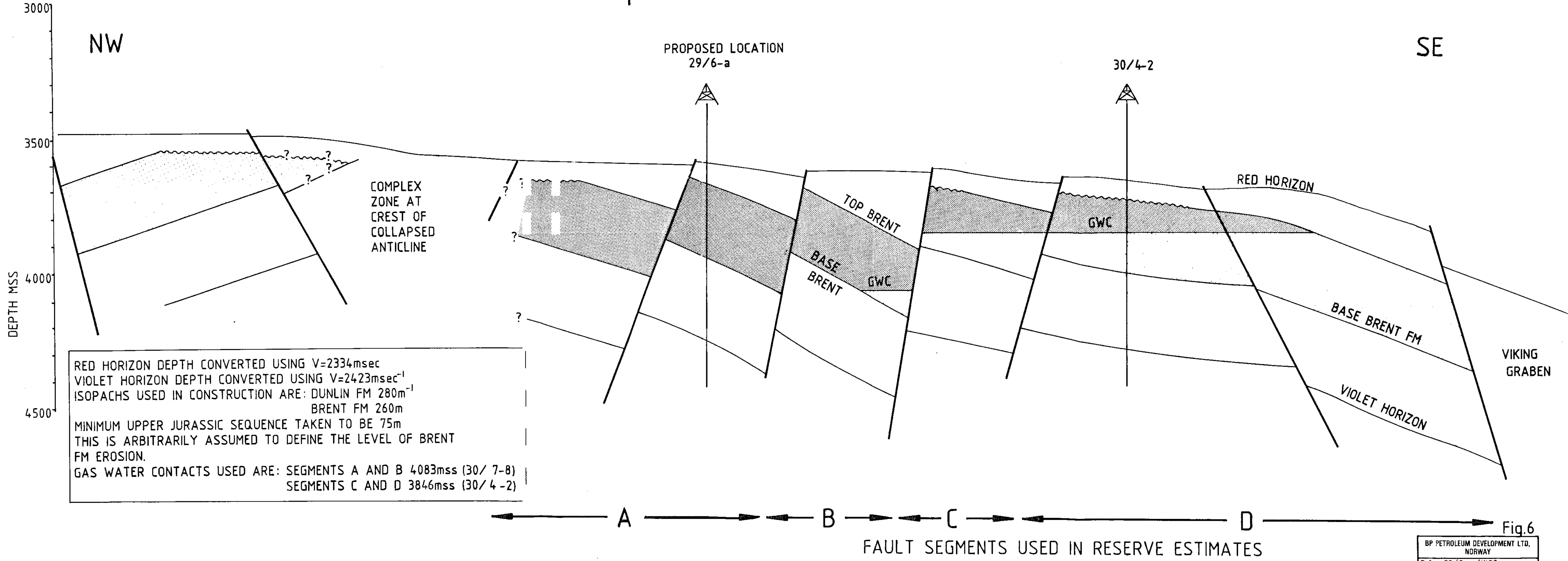


Fig.6

BP PETROLEUM DEVELOPMENT LTD, NORWAY
Ref: 29/6-a /W20
Author: D DALTON
Date: Sept 1981 | Drg No: 5622

PRESSURE v DEPTH PLOT USING RFT DATA FROM 30/7-6, 30/7-8 AND 30/4-2

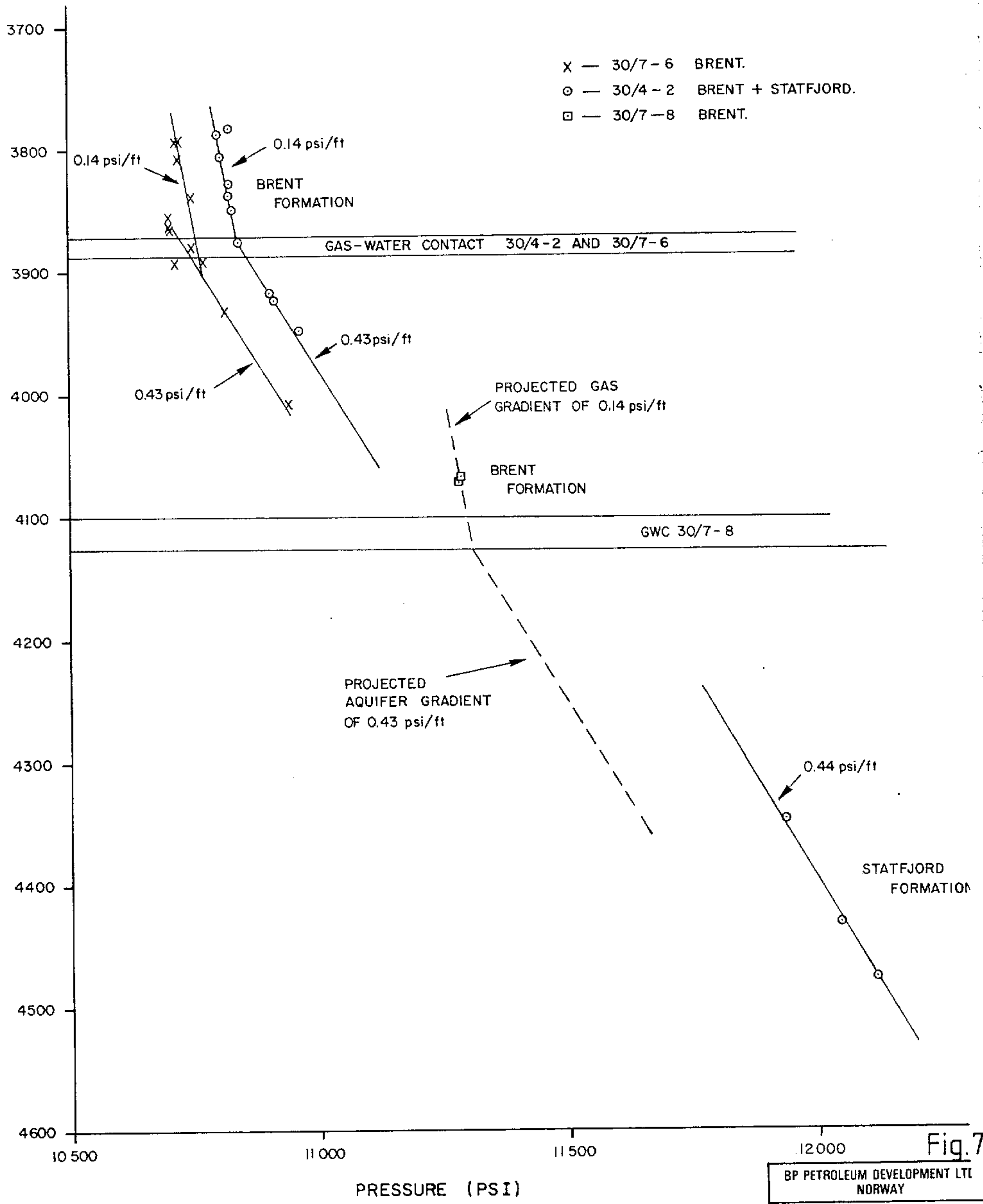


Fig.7

BP PETROLEUM DEVELOPMENT LTD NORWAY	
Ref: 29/6 - a/W 20	
Author: D.DALTON	
Date: JUNE-81	Drg No: 5334

b) the Base Brent Formation does not subcrop but a trap is created either by dip closure over the crest of the anticline or fault seal to the west.

c) there is no trap within the Brent Formation and any hydrocarbons have spilled to the N or W.

Regional pressure data shows that the Brent Formation in the wells on the β structure are 1500 psi overpressured with respect to the wells in block 3/15. There must therefore be a pressure discontinuity between 3/15-4 and 30/7-8. However this could take the form of a fault seal or the subcrop of the Brent Formation and it could lie anywhere between the two wells.

At Statfjord level there is likely to be closure against the faults bounding segments B to D. Closure may also exist at Statfjord level beneath the crest of the anticline.

In summary, the β structure in licence 043 comprises a number of separate potential traps at both Brent and Statfjord levels. Four main fault segments are recognised, three of which have fault and dip closures at both Brent and Statfjord levels. The Brent Formation has been tested in two of these traps and found to contain gas condensate. The fourth most westerly fault segment has no mapped closure, but subcrop or dip/fault trapping may exist in the Brent Formation and the Statfjord Formation.

3.2 Reservoir

a) The Brent Formation is the main reservoir horizon on the structure and can be divided into three units. The reservoir properties of these three units are summarised in Table 1. The upper massive sandstone is the Tarbert Member and represents a sequence of distributary channel and mouth bar sandstones. This unit contains the best reservoir intervals. The interbedded unit is the Ness Member and it is interpreted as a delta top sequence. Overbank and levee

TABLE 1

RESERVOIR CHARACTERISTICS OF THE BRENT FORMATION

		30/4-2[1]	30/7-6[2]	30/7-8[3]
TARBERT MBR.	Gross Thickness (m)	82	95	94
	Net/Gross Ratio	0.83	0.78	0.45
	Average Porosity	0.23	0.19	0.20
	Water Saturation	0.10	0.17	0.25
NESS MBR.	Gross Thickness (m)	162	141	25+
	Net/Gross Ratio	0.25	0.10	Not fully penetrated
	Average Porosity	0.21	0.17	" " "
	Water Saturation	Water bearing		" " "
ETIVE, RANNOCH AND BROOM MBRS.	Gross Thickness (m)	37	29	Not penetrated
	Net/Gross Ratio	0.30	~~0.45~~ 0.05	" "
	Average Porosity	0.22	0.17	" "
	Water Saturation	Water bearing		" "

1. Figures for 30/4-2 derived from Musgrave and Buckley 1980.
2. Figures for 30/7-6 derived from Scotton, August 1981.
3. Figures for 30/7-8 derived from Scotton, September 1981.

mudstones and coals are interbedded with crevasse splay and channel fill sands. The lower massive sandstone comprises the Etive, Rannoch and Broom Members which are interpreted as being mouth bar and delta front sandstones.

b) The Statfjord Formation is the secondary target on the structure. It was penetrated by 30/4-2 and found to be water wet with the following reservoir properties (Musgrave and Buckley 1980):

- Gross Thickness 333 m
- Net/Gross Ratio 0.52
- Average Porosity 0.15

The Statfjord Formation is a sandstone sequence representing a transition from continental to marine conditions. The upper part of the formation is good quality massive sandstone known as the Nansen Member. This had a thickness of 54 m in 30/4-2.

4 RESERVES

Reserves for the β prospect have been calculated by PE Dept., Stavanger (Abbott, 1981). A summary of these calculations and the input parameters used are given in Tables 2 and 3.

The BRVs were calculated for each of the four fault segments (A to D) separately. The maps used were interim maps produced by Ward and not the latest maps presented in this report. Revised reserves based on the latest maps would show only small differences from the figures given here. The BRVs for fault segments D and B were calculated using the GWCs determined in 30/4-2 and 30/7-8 respectively.

For segment C the BRV was calculated assuming the same GWC as 30/4-2.

A triangular distribution of BRVs was employed for segment A in order to accomodate the high degree of uncertainty involved in the mapping of the segment. The most likely case assumed a 'moderate' degree of subcrop of the Brent Formation beneath the Upper Jurassic Heather Formation. The minimum case was arbitrarily taken as half the most likely case. The maximum case assumed no subcrop of the Brent Formation beneath the Heather Formation.

The reservoir parameters used in the reserve calculation were weighted averages based on data from 30/4-2, 30/7-6 and 30/7-8 (see Table 1 and 2). An attempt has been made to estimate the proportion of the BRV represented by each member within the Brent Formation. This is desirable because of the variation in reservoir parameters between the members. This was done by simply estimating the proportion of each member lying above the GWC on an areal basis, from a scaled crossection.

The reserve estimates indicate that in total there could be between 1.3 and 2.8 Tscf gas in place in the structure in licence 043. Of this 0.7 Tscf lie in fault segments B, C and D and hence can be considered to be 'proven'. The remaining 0.6 to 2.1 Tscf lying in fault segment A must be considered to be 'possible' reserves. It is these possible reserves that the 29/6-a well is designed to prove up.

TABLE 2

PARAMETERS USED IN RESERVE CALCULATIONS

BRV (MM m^3)

		Whole Field	Licence 043 (29/6, 30/4)
SEGMENT A	Min.	1658	902
	Most likely	3315	1804
	Max.	4743	2279
SEGMENT B		495	372
SEGMENT C		48	46
SEGMENT D		535	268

PETROPHYSICAL PARAMETERS

Weighted averages from Table 1.

	Net/Gross	Porosity	Water saturation
TARBERT MBR.	0.68	0.21	0.16
NESS MBR.	0.18	0.20	use 0.2
ETIVE, RANNOCH AND BROOM MBRS.	0.19	0.22	use 0.2

GAS EXPANSION FACTOR: 381

TABLE 3

SUMMARY OF RESERVE ESTIMATES
(Taken from Abbott 1981)

GAS IN PLACE (Tscf)

	TOTAL	% IN LICENCE 043
SEGMENT A 'Low'	1.02	54
'Most likely'	2.05	54
'High'	4.31	48
SEGMENT B	0.55	75
SEGMENT C	0.08	96
SEGMENT D	0.50	50
TOTAL B+C+D	1.13	65
TOTAL A+B+C+D 'Low'	2.15	60
'High'	5.44	51

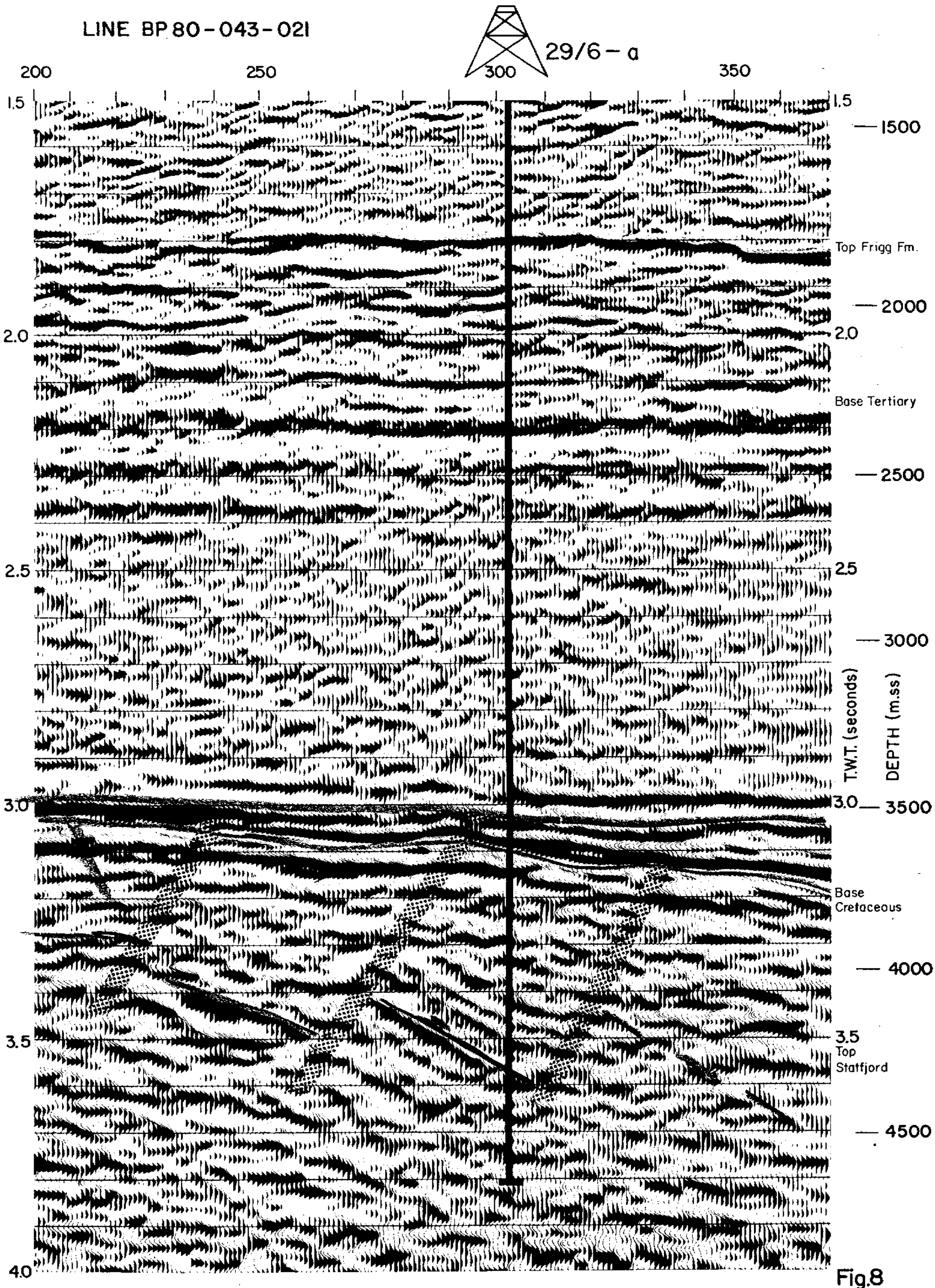


Fig.8

SEISMIC LINE THROUGH PROPOSED WELL LOCATION 29/6-a

BP PETROLEUM DEVELOPMENT LTD, NORWAY
Ref: 29/6-a / W20
Author: R.W. Ward

5 CHOICE OF LOCATION

The main objective of this well is to define the overall reserves of the β structure to aid economic studies for possible development. Fault segments B and D have already been shown by previous wells to be gas bearing and gas-water contacts established. Likely reserves on segment C are relatively small even if the GWC is deeper than predicted (continuity with segment D). Establishment of reserves within segment A will have the greatest impact upon the future of β prospect.

Segment 'A' has 2 fault compartments of which the eastern one is preferred since local fault closure is clearly demonstrated whilst the closure on the western one is uncertain at the crest of the collapsed anticline. A necessary criterion is that the location lies on a good quality (migrated) seismic line where there is little chance of the well cutting any Jurassic fault. Two lines met this qualification, BP-80-021 (fig. 8) and BP-80-019, and the site survey was designed to cover possible location on either line. Maps of base Cretaceous, Top Brent, Top Statfjord for segment A are presented on Figs. 9-11. Relative position on the fault block is similar for a location on either line; BP-80-021 lies at the intersection of 3 site survey lines and a line from the 1981 seismic survey has also been shot through this location.

The location is located within predicted closure on the top Brent Fm form map (Fig. 10) 200 ms above the estimated GWC (3320 ms TVT). At the top Statfjord Fm (the Violet Horizon) the location is very close to mapped closure (Fig. 11).

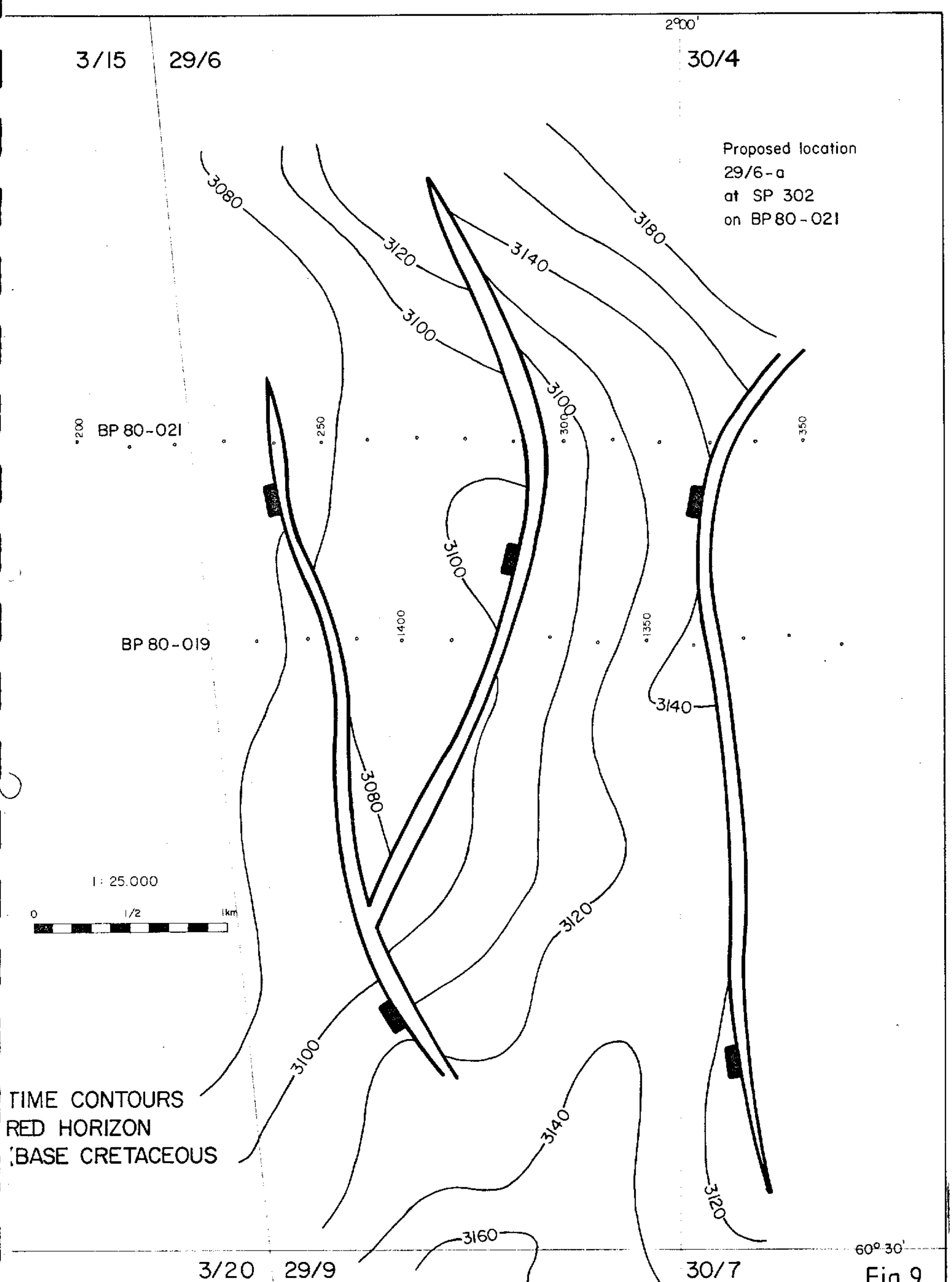
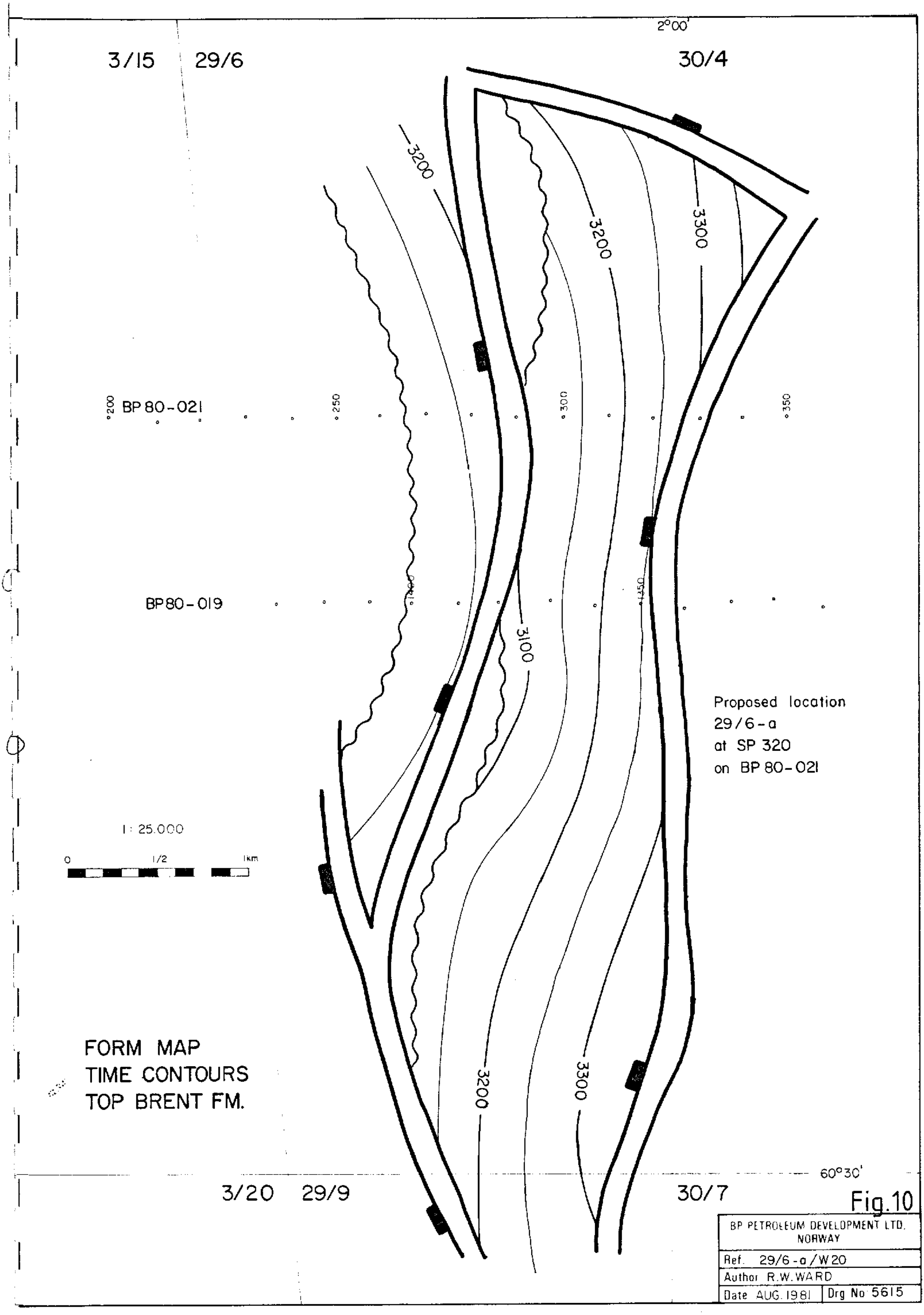


Fig. 9

BP PETROLEUM DEVELOPMENT LTD. NORWAY	
Ref: 29/6-a/W20	
Author: R.W. WARD	
Date: AUG. 1981	Drg No: 5614


3/15
29/6
2°00'
30/4
3200
3300
3200
BP 80-021
200
250
300
350
BP80-019
3100
Proposed location
29/6-a
at SP 320
on BP 80-021
1: 25.000
0
1/2
1km
FORM MAP
TIME CONTOURS
TOP BRENT FM.
3200
3300
60°30'
3/20
29/9
30/7
Fig.10
BP PETROLEUM DEVELOPMENT LTD.
NORWAY
Ref. 29/6-a/W20
Author R.W.WARD
Date AUG.1981
Drg No 5615

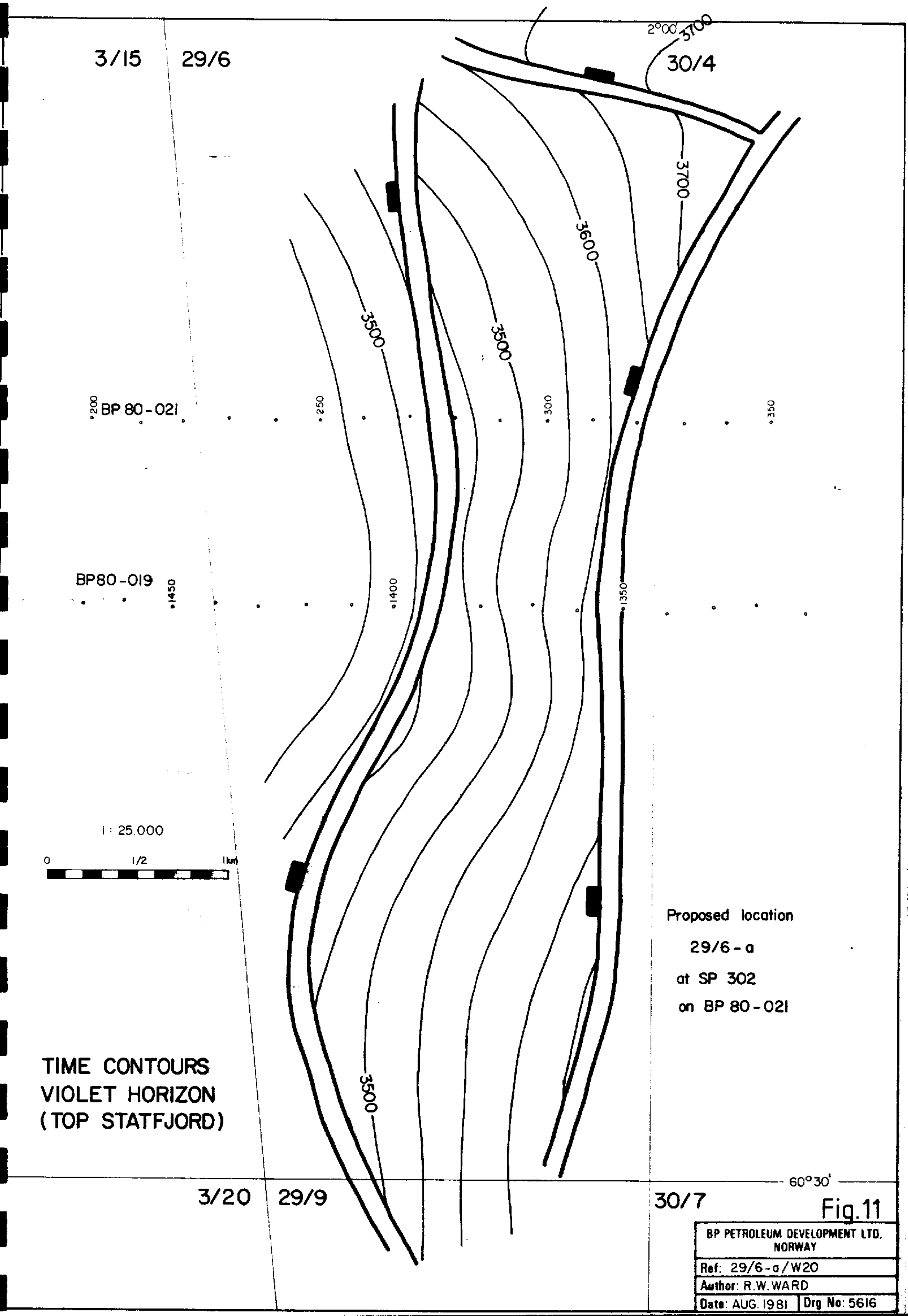

3/15
29/6
30/4
2°00'
3700
3600
3500
3500
3500
3500
BP 80-021
200
250
300
350
BP80-019
1450
1400
1350
1 : 25.000
0
1/2
1km
Proposed location
29/6 - a
at SP 302
on BP 80-021
TIME CONTOURS
VIOLET HORIZON
(TOP STATFJORD)
3/20
29/9
30/7
60°30'
BP PETROLEUM DEVELOPMENT LTD. NORWAY
Ref: 29/6-a/W20
Author: R.W. WARD
Date: AUG. 1981
Drg No: 5616

Fig.11

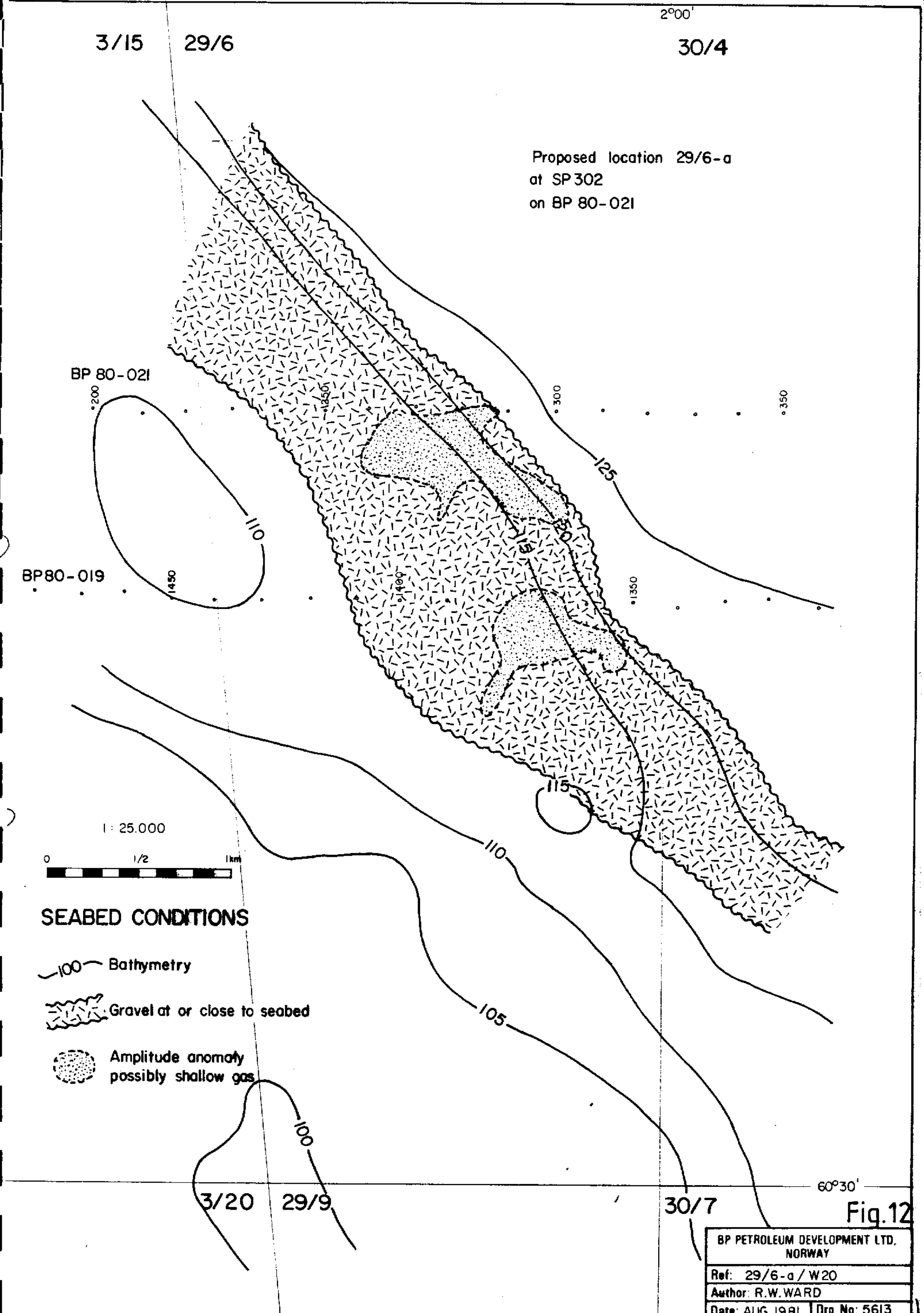


Fig.12

BP PETROLEUM DEVELOPMENT LTD. NORWAY	
Ref: 29/6-a / W20	
Author: R.W. WARD	
Date: AUG. 1981	Drg No: 5613

6. STRATIGRAPHIC FORECAST

6.1 Seismic Forecast

Velocities for the seismic forecast are based on regional studies because of lateral velocity variations in addition to compaction effects. Velocity/Depth plots of Tertiary data show a set of regression curves with increasing velocities northwards and westwards. There is a good regional velocity - depth correlation for the Cretaceous but locally on structure there is a low velocity anomaly which affects 30/4-2 and 30/7-6. There is more scatter on Jurassic velocity-depth plots but the 30/4-2 value should be reliable.

TABLE 4

SEISMIC FORECAST

Seismic Horizon	Geological Horizon	T	Δ T	V	VI	Z	E
	seabed	-	-	-	-	125	-
Golden Brown	Top Frigg Fm	1.780	.015	2045		1805	±20
					2745		
Yellow	Base Tertiary	2.175	.025	2170		2330	±40
					2900		
Red	Base Cretaceous	3.100	.035	2390		3670	±90
					2940		
Violet	Top Statfjord	3.545	.035	2460		4315	±200

T is migrated Two Way seismic time (in seconds)

Δ T is seismic lag (in seconds)

V is average velocity (in metres/sec)

VI is interval velocity (in metres/sec)

Z is predicted depth (subsea) (in net res)

E is error (in metres)

WELL LOCATION 29/6-a
GEOLOGICAL FORECAST

6711946 N 444576 E
LOCATION 60°32'17·87"N, 1°59'23·68"E

SCALE 1:10,000

Stratigraphic Unit		Depths (metres subsea)	M & Ft	Seismic Event	Lithology	Drilling Problems
QUAT.		128		SEA BED		
TERTIARY			250 / 1000		SAND fine to medium grained with glauconite and shell fragments.	
			500 / 2000		Occasional interbeds of CLAY green, soft, silty.	
			750		Occasional LIGNITE beds.	
			3000 / 1000		MUDSTONE grey green, soft, slightly micaceous, non calcareous, with SILTSTONE brown, very argillaceous.	
			4000 / 1250			
			1500 / 5000		SANDSTONE very fine grained, occasional calcite cemented.	
					MUDSTONE grey, soft with stringers of dolomitic LIMESTONE	
			1750	GOLDEN-BROWN		
ROGALAND GP	FRIGG FM	1805	6000		SANDSTONE fine to medium grained, occasionally cemented with calcite.	
	MONTROSE GROUP				MUDSTONE grey, occasionally vari-coloured, tuffaceous.	
			2000 / 7000 / 2250		Interbedded SANDSTONES fine to medium grained, well cemented with calcite and MUDSTONE grey, soft, calcareous.	
CRETACEOUS	SHETLAND GROUP	2330	8000 / 2500	YELLOW	MUDSTONE grey soft, sticky, very calcareous, silty, with stringers LIMESTONE white, buff, occasionally dolomitic, occasionally sandy.	OVERPRESSURING IN SHALES STARTS APPROX 2300 mss
			9000 / 2750			
			3000 / 10000		Occasional DOLOMITE stringers, brown, hard.	
			3250 / 11000			
			3500	LIGHT BLUE		
JURASSIC	HUMBER GP	3610 / 3670	12000 / 3750	RED	MUDSTONE dark grey to black, hard, calcareous, carbonaceous.	
	BRENT FM	3775	1300 / 4000		SANDSTONE medium to coarse grained, commonly micaceous, occasionally calcite cemented with interbeds of MUDSTONE grey, hard, very micaceous, carbonaceous with COAL beds.	
	DUNLIN FM	4035	4250 / 1400		MUDSTONE grey, hard, subfissile, with occasional beds SANDSTONE/SILTSTONE argillaceous, micaceous.	
	STATFJORD FM	4315	4500	PURPLE	SANDSTONE medium to coarse grained with interbeds MUDSTONE grey to grey green, hard, silty, non calcareous.	
TRIASSIC	CORMORANT FM	4650			MUDSTONE red brown, soft, silty. SANDSTONE very fine to medium grained.	
					PROPOSED TD 4700 mss	

Graphic Log:

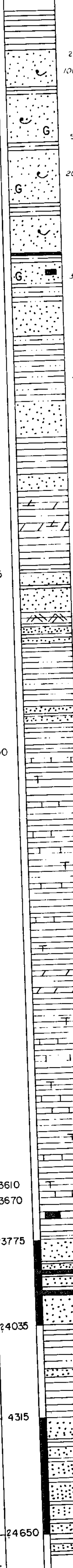


Fig.13

BP PETROLEUM DEVELOPMENT LTD. NORWAY	
Ref: 29/6-a/W 20	
Author: D.G. DALTON	
Date: JUNE 81	Drg No: 5336

6.2 Geological Forecast (Fig. 13)

The stratigraphic sequence at the 29/6-a location is expected to be similar to the other β structure wells.

In the Tertiary sequence the Frigg Formation is the first formation of interest. It is predicted to be composed of good reservoir quality, sandstones approximately 140 m thick. The 29/6-a location is outside closure on the Golden-Brown Horizon (Top Frigg Fm.) and so the sandstones are expected to be water wet. Poor quality sandstones are also expected in the Montrose Group but they have not contained hydrocarbons in any of the other wells on the β structure and are not expected to do so on the 29/6-a location.

The Cretaceous Sequence is expected to be predominantly mudstones with minor limestone beds. These mudstones are likely to be overpressured with a transition zone near the top of the Shetland Group (2330 mss). No significant hydrocarbon accumulation is expected within the Cretaceous section.

The Base Cretaceous unconformity is predicted to be at 3670 mss and beneath that an Upper Jurassic mudstone section is expected. As discussed previously in this report there is considerable doubt as to the thickness of this section, which could vary between 35 and 250 m. Below the Upper Jurassic Heather Formation, the Brent Formation is the main target and is likely to be highly overpressured. The Tarbert Member at the top of the Brent Formation is predicted to be complete at the well location, however it is possible that an eroded sequence may be encountered. The maximum thickness of reservoir is predicted to be 280 m.

The Dunlin formation at the base of the Brent formation is likely to be predominantly mudstones, although theremay be minor sandstone beds which could be hydrocarbon bearing.

The top Statfjord Formation is predicted at 4315 mss and is expected to be about 335 m thick and underlain by red mudstones and minor sandstones of the Cormorant Formation.

The proposed TD of the well is 50 m beneath the top Cormorant Formation or 50 m into the Statfjord Formation if the latter proves to be water wet.

7 CONCLUSIONS

1. The β prospect in the SW corner of licence 043 has been remapped following the receipt of new seismic lines (Total 1978 survey, BP 1980 survey) and data from 30/7-8. Isochron maps on the Red and Violet Horizon are presented here. Although the data quality beneath the Red Horizon (Base Cretaceous) is very poor four N-S fault segments have been mapped (A to D).

2. The top of the Brent Fm. (the primary target) can not be mapped seismically and therefore a form map had to be constructed by isopaching up from the Violet Horizon (Top Statfjord Fm.) This construction is complicated by the erosion of the Brent Fm from the tops of the Jurassic fault blocks. The amount and level of this erosion is defined by the thickness of the overlying Upper Jurassic Humber Group. Data from nearby wells was used to try and predict the thickness of the Jurassic sequence across the β structure but it was found to vary considerably and unpredictably. The top Brent Fm. form map was finally constructed using a constant Upper Jurassic thickness of 75 m (60 msecs), i.e. the 30/4-2 section.

3. The four fault segments (A to D) represent the eastern limb of a complex collapsed anticline. The axis of the anticline lies close the median line and the Brent Fm is thought to be missing over the crest.

   Fault segments D and B are proven gas condensate accumulations with separate spill points and hence GWC's.

   Fault segment C is untested but is small and thought to have the same GWC as segment D. Fault segment A has more uncertainties but if it contained gas would significantly add to the reserves of the prospect.

4. Reserves for fault segments B, C and D are estimated as 0.7 Tscf in place (in licence 043). Additional reserves in segment A are estimated as beween 0.6 and 2.1 Tscf (in place in licence 043).

5. A well location is proposed to test fault segment A. The main criterion for the choice of the location was that it should lie on a good quality seismic line where there is little chance of the well cutting a Jurassic fault. The location was chosen on line BP 80-043-021 at SP 302.

6. The forecast is that the well will encounter highly pressured gas bearing Brent Fm. sandstones at 3775 mss. However there is considerable uncertainty regarding this prediction and there may be an error of up to 200m.

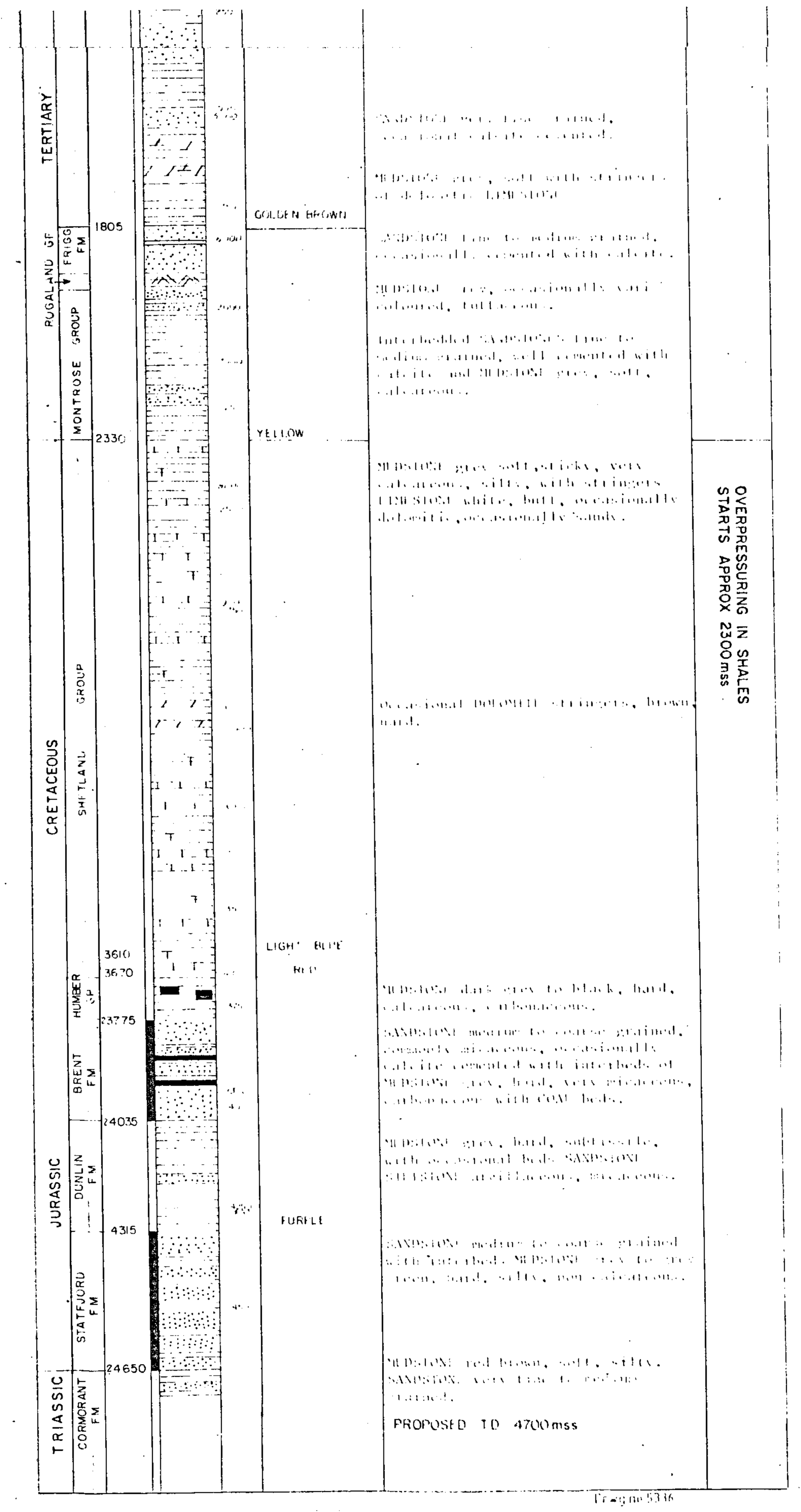
8. RECOMMENDATIONS

It is recommended that the third and final commitment well in licence 043 be located on the β prospect in the hope of proving up enough reserves to make the field economically viable. To do this reserves must be proven in fault segement A where the location is proposed.

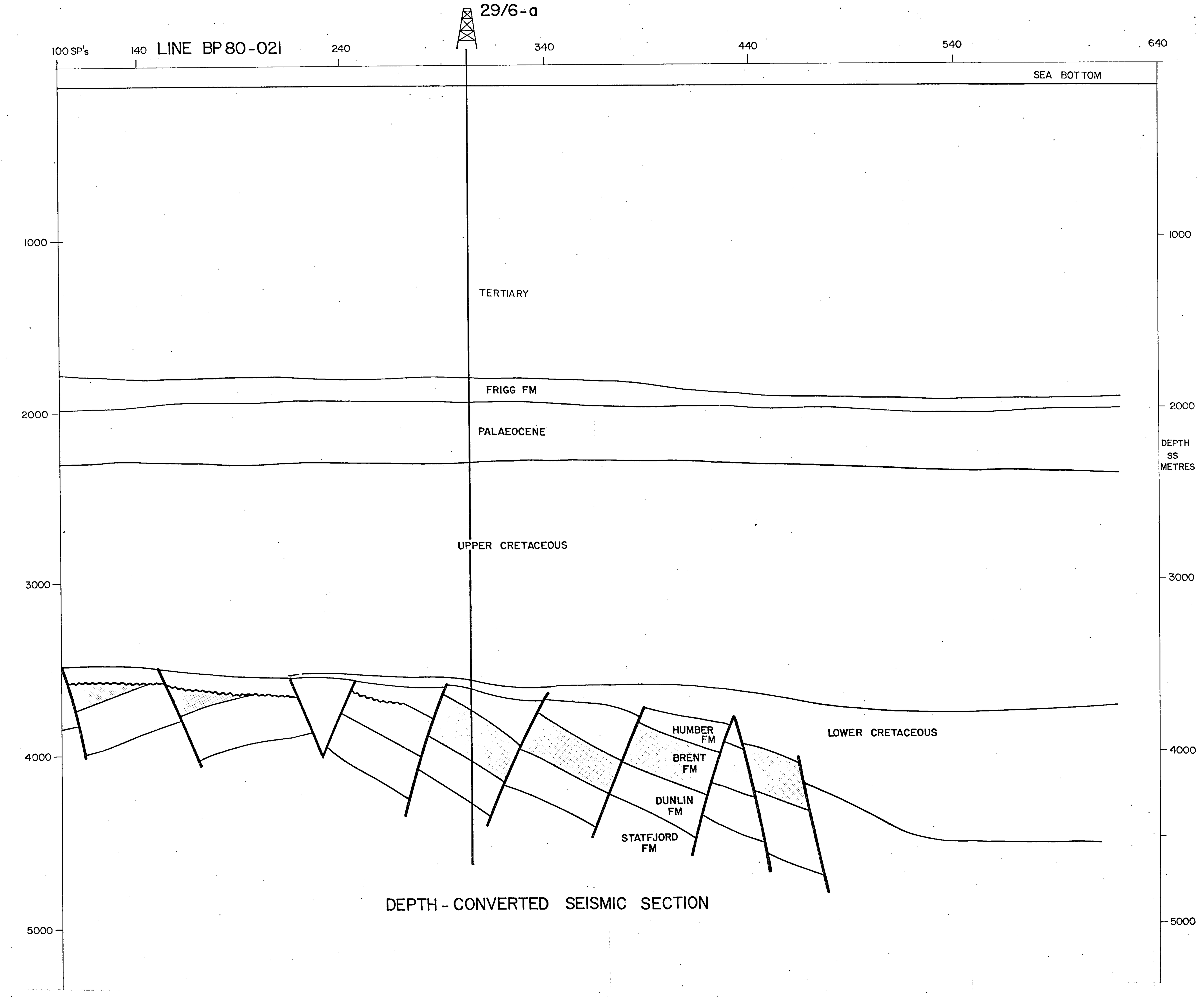
It is recommended that the well should be drilled to test the Brent Fm. primarily and the Statfjord Fm. as a secondary target. The Brent Fm. should be cored throughout the hydrocarbon interval and that interval should also be tested.

9. REFERENCES

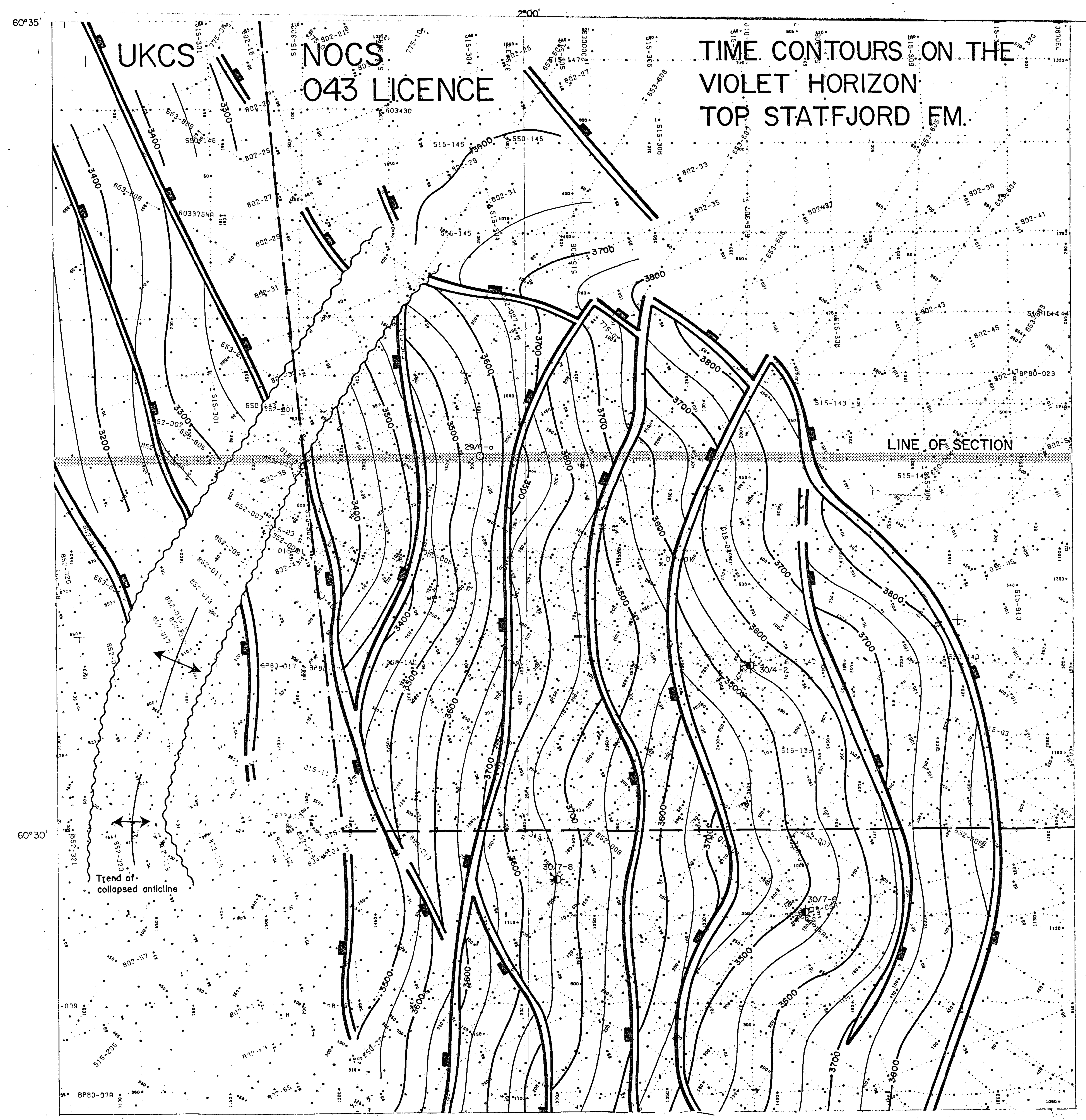
1.	Abbott, B.F.M.	Petroleum Engineering Evaluation of Licence 043 Gas Discovery (in prep.).
2.	Allan, P.M.	Licence 043: Geophysical re-evaluation of the β prospect - GP/NO/180 (in prep.).
3.	Buckley, P. and Spencer, A.M. 1980	An evaluation of the 30/4-2 Gas Discovery prepared, for NPD - GP/NO/442.
4.	Dalton, D.G. 1980	Completion Report NOCS 30/4-2 - 30/4-2/W28.
5.	Dalton, D.G. and Allan, P.M. 1980	Evaluation of NOCS 30/4-2 - 30/4-2/W27.
6.	Deegan, C.E. and Scull, B.J. 1977	A standard lithostratigraphic nomenclature for the Central and Northern North Sea - GL/NO/098.
7.	Drake, S.J. 1979	Completion Report NOCS 30/4-1 - 30/4-1/W28.
8.	Musgrave, F. and Buckley, P.S. 1980	Petroleum Engineering Completion Report - Well 30/4-2 - 30/4-2/W45.
9.	Pape, J. and Goff, J.C. 1979	Geophysical re-evaluation of SW corner licence 043 - GP/NO/120.
10.	Scotton, G.	File note: Log Evaluation - Well 30/7-8 (2.7.81) 30/7-8/W48.
11.	Scotton, G.	File note: Log Interpretation of Brent Fm in 30/7-6 30/7-6/W48 (20.8.81).



LINE BP 80-043-021 (MIGRATED)



DEPTH - CONVERTED SEISMIC SECTION



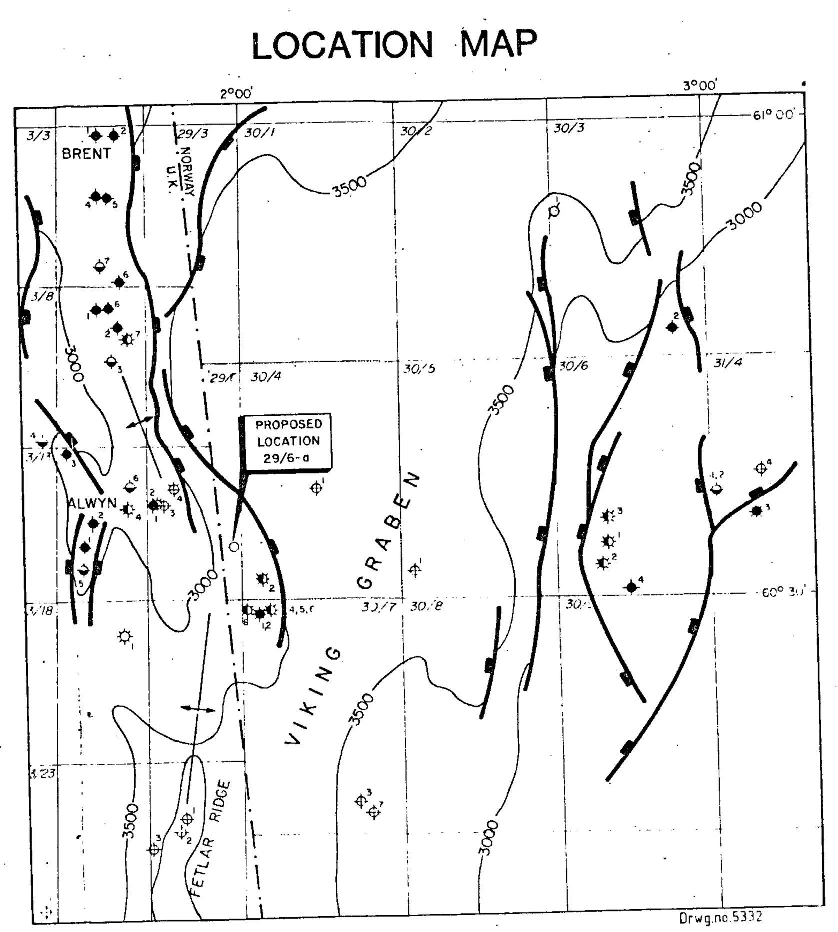
ENCL. 1

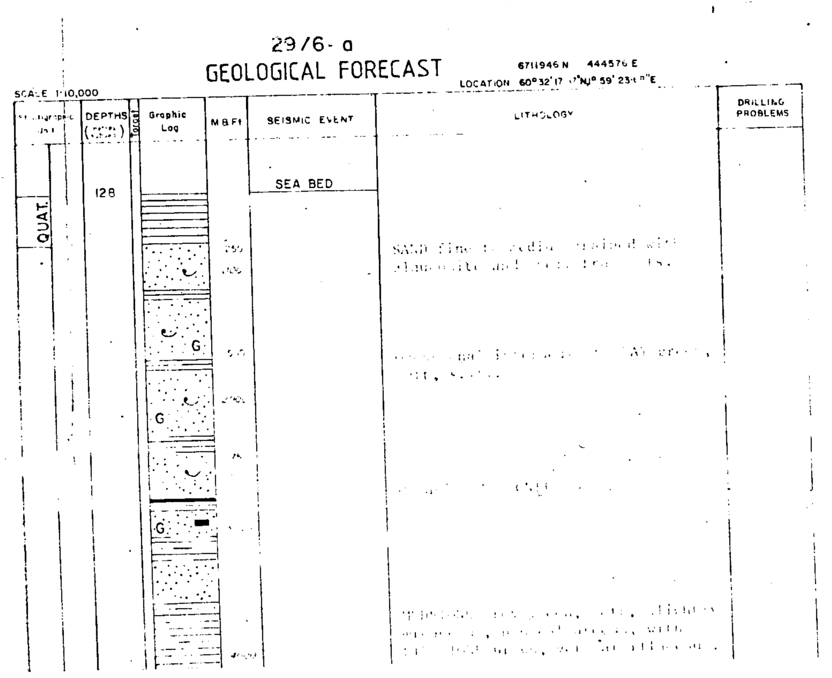
BP PETROLEUM DEVELOPMENT LTD. NORWAY

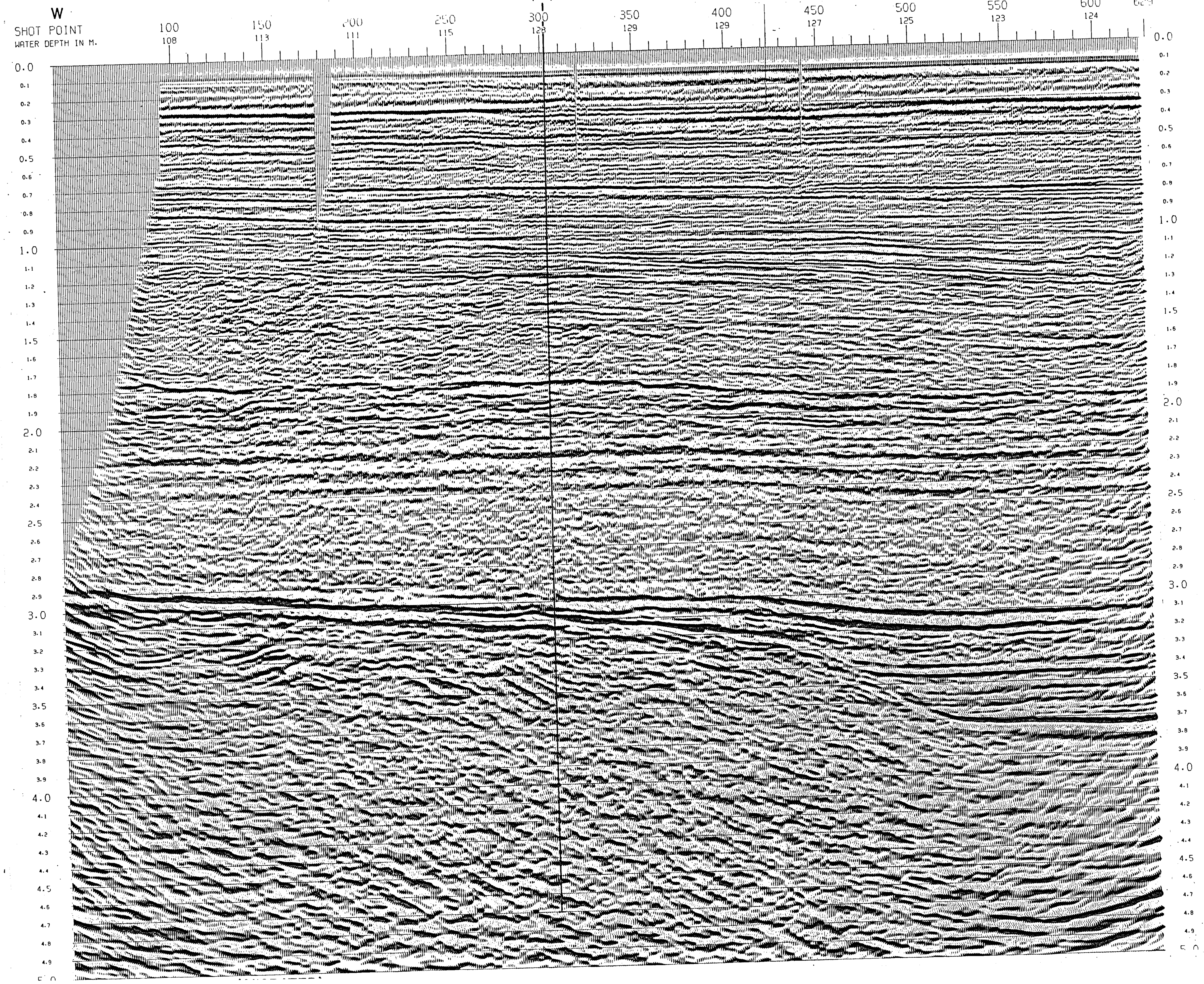
LICENCE 043,B PROSPECT

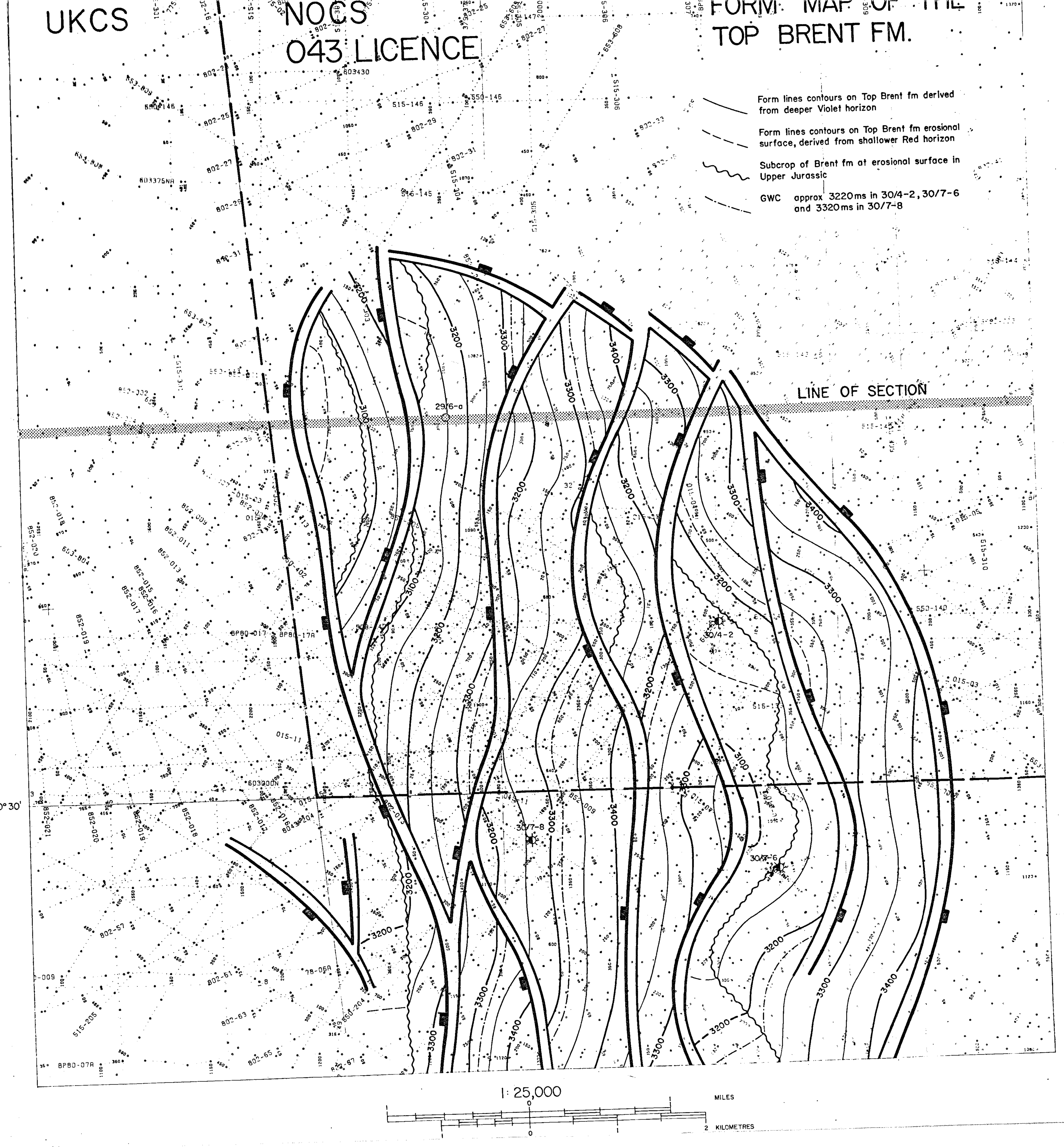
PROSPECT MONTAGE
29/6-a DRILLING PROPOSAL

Ref:	29/6-a/W20	Datum:	
Author:	Dalton/Ward	Scale:	
Date:	Sept. 1981	Drg. No:	5630

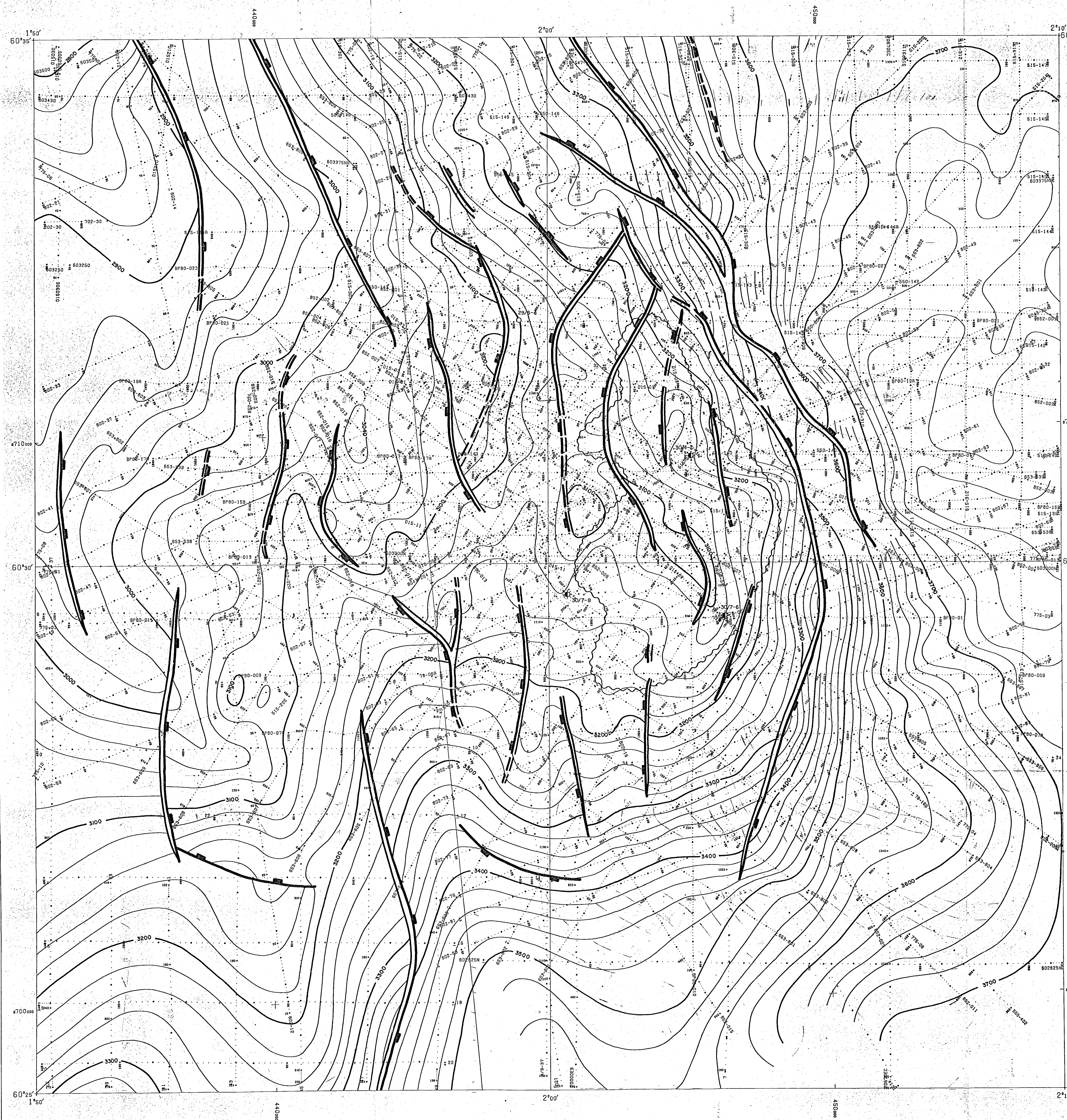

LOCATION MAP
BRENT
PROPOSED LOCATION 29/6-a
VIKING GRABEN
FETLAR RIDGE
Drwg.no 5312


29/6-a
GEOLOGICAL FORECAST
QUAT
128
SEA BED


W
SHOT POINT
WATER DEPTH IN M.
100
150
200
250
300
350
400
450
500
550
600
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5


UKCS
NOCS
043 LICENCE
FORM MAP OF THE
TOP BRENT FM.
Form lines contours on Top Brent fm derived from deeper Violet horizon
Form lines contours on Top Brent fm erosional surface, derived from shallower Red horizon
Subcrop of Brent fm at erosional surface in Upper Jurassic
GWC approx 3220ms in 30/4-2, 30/7-6 and 3320ms in 30/7-8
LINE OF SECTION
29/6-a
60°30'
1:25,000
MILES
KILOMETRES

1:25000



Approximate area of very poor data quality where low velocity anomaly has also caused depressed time values.

MILES
KILOMETRES

UNIVERSAL TRANSVERSE MERCATOR
SPHEROID: INTERNATIONAL
ZONE 31- C.M.3.00 °E- NORTHERN HEMISPHERE
GRID UNITS ARE METRES

ENCL. 2

BP PETROLEUM DEVELOPMENT LTD. NORWAY

LICENCE 043-SW CORNER

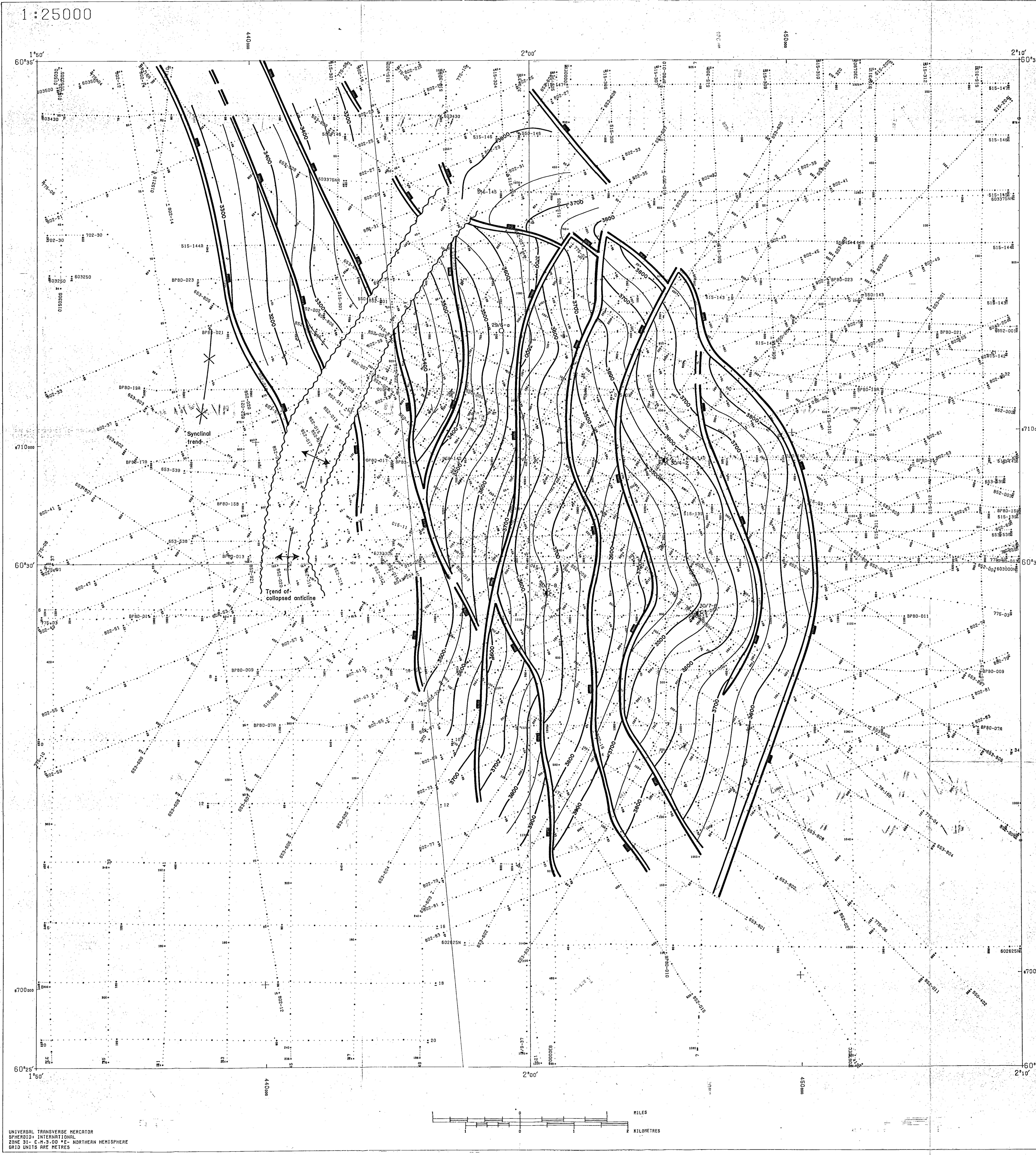
MARINE REFLECTION SURVEY

TIME CONTOURS ON THE RED HORIZON

(BASE CRETACEOUS UNCONFORMITY)

MIGRATED TIMES CI 20 ms

REF:	29/6-a W-20	DATUM:	MSL
AUTHOR:	R.W.WARD	SCALE:	1:25000
DATE:	AUGUST 1981	DRG NO:	5554



The Violet Horizon is assumed to represent Top Statfjord formation.
It ties to well control at 30/4-2 and fits extrapolated values at 30/7-6, 30/7-8 which have not penetrated this deep
Elsewhere correlation is uncertain, mapping is doubtful and contours are shown as solid lines rather than dashed ones merely for clarity
The map was constructed using only migrated dip lines of very poor data quality

ENCL. 3

BP PETROLEUM DEVELOPMENT LTD. NORWAY

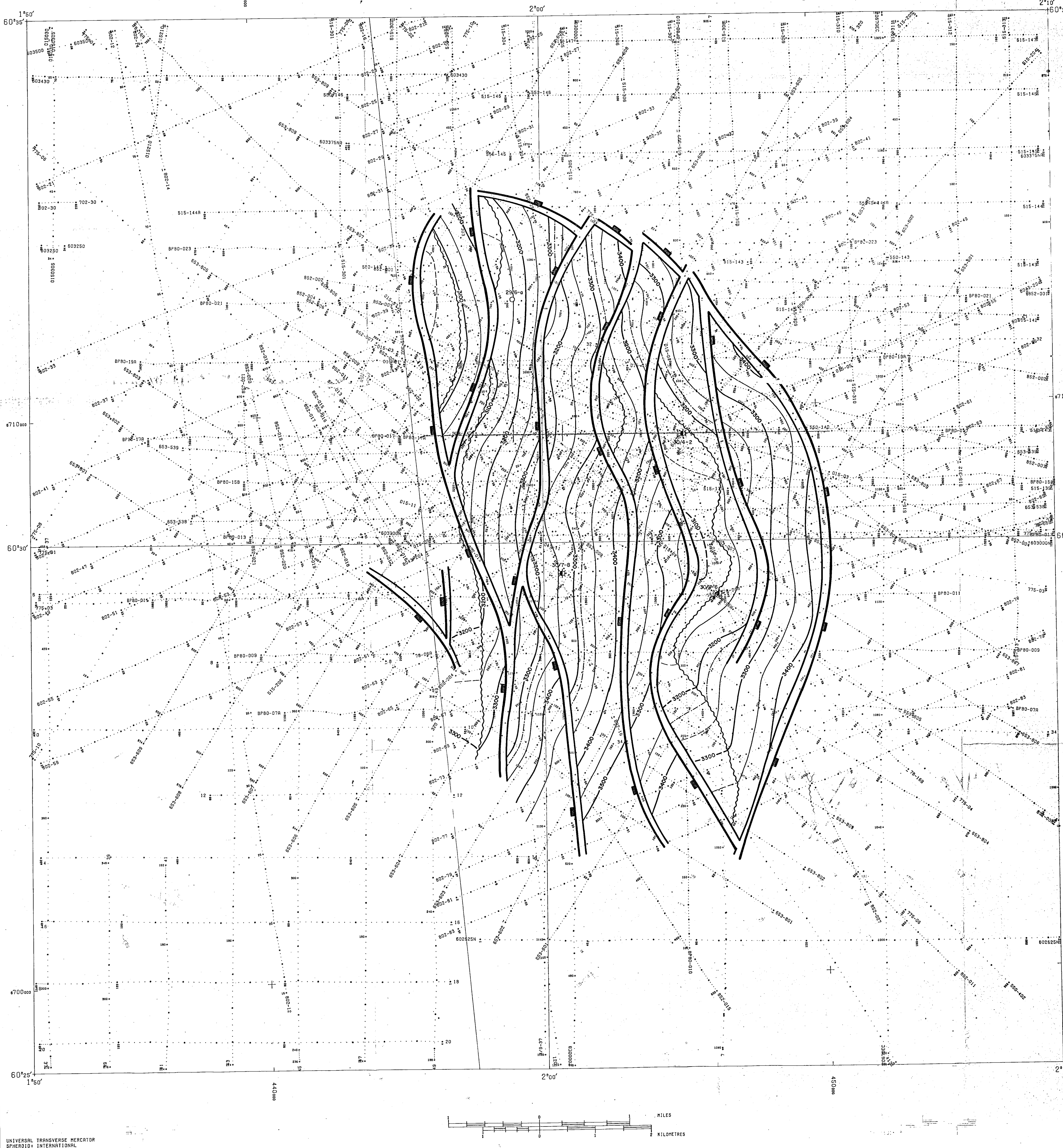
MARINE REFLECTION SURVEY

TIME CONTOURS ON THE VIOLET HORIZON

CI 50ms

REF: 29/6-a W-20	DATUM: MSL
AUTHOR: R.W. WARD	SCALE: 1:25000
DATE: AUGUST 1981	DRG NO: 5606

1:25000



Form lines contours on Top Brent fm derived from deeper Violet horizon

Form lines contours on Top Brent fm erosional surface, derived from shallower Red horizon

Subcrop of Brent fm at erosional surface in Upper Jurassic

GWC approx 3220ms in 30/4-2, 30/7-6 and 3320ms in 30/7-8

UNIVERSAL TRANSVERSE MERCATOR
SPHEROID: INTERNATIONAL
ZONE 31- C.M.3.00 °E- NORTHERN HEMISPHERE
GRID UNITS ARE METRES

ENCL. 4

BP PETROLEUM DEVELOPMENT LTD. NORWAY

MARINE REFLECTION SURVEY

FORM MAP OF THE TOP BRENT FM

CI 50ms

REF:	29/6-a W-20	DATUM:	MSL
AUTHOR:	R. W. WARD	SCALE:	1:25000
DATE:	SEPTEMBER 1981	DRG NO:	5611