ON-LINE T.D.C. REPORT

NORSKE SHELL

WELL 31/2-6

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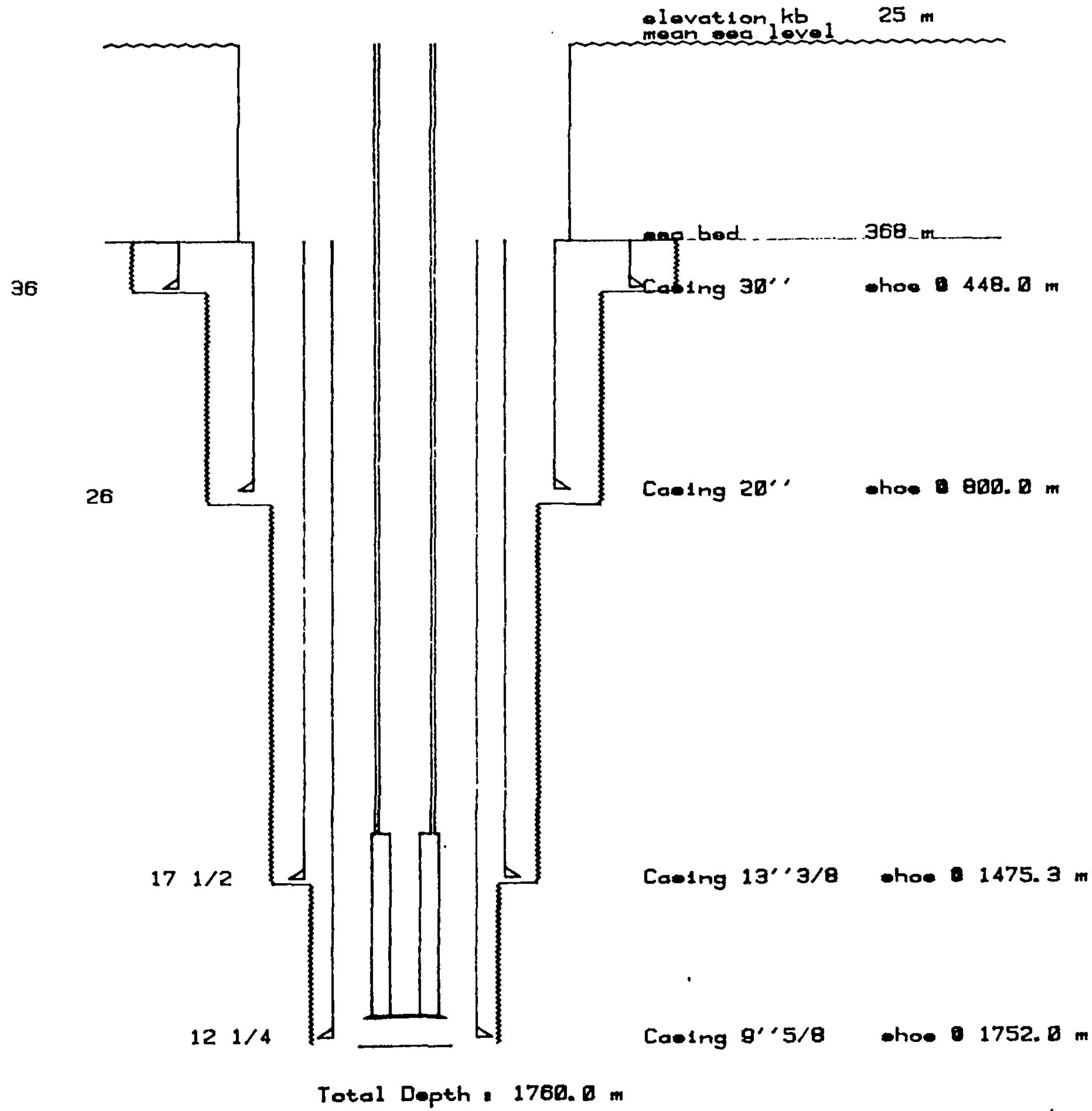

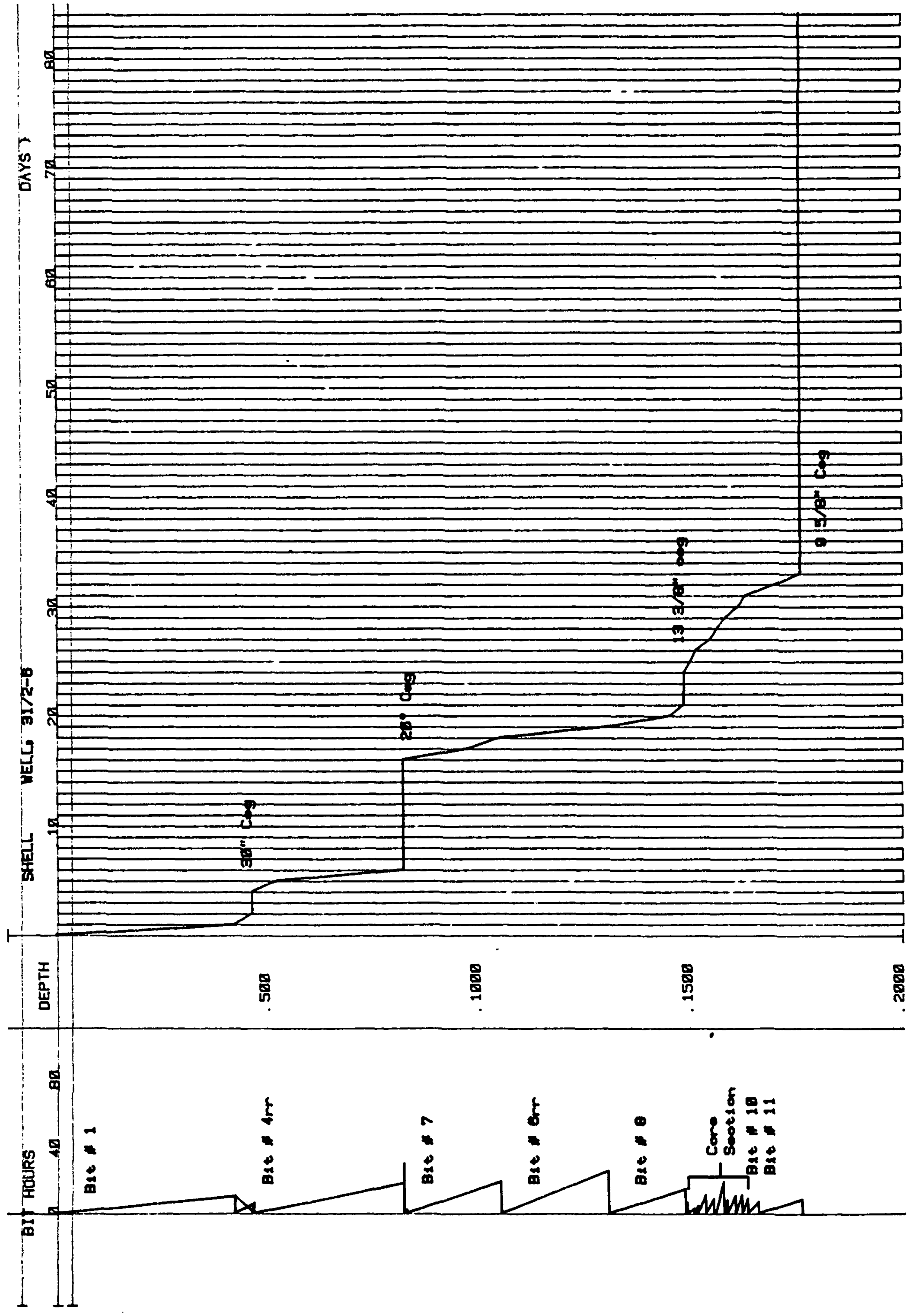
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PROPOSALS AND OBJECTIVES

To drill an exploration well on Block 31/2 approximately 119 Km NW of Bergen on the eastern side of the Norwegian Trench, at location 60° 54', 14.2" N, 03 49.8" E positioned with diametric tolerance of 75m.

FIVE OBJECTIVES WERE PROPOSED FOR THE WELL

a) To test the gas accumulation at its north-eastern most margin.

b) To evaluate the lateral variation in reservoir parameters.

c) To test the oil zone in a good sand reservoir.

d) To "prove" hydrocarbon communication between blocks 31/2 and 31/3.

e) To get reliable geologic tie to the seismic reflectors to allow for accurate lateral extrapolation of well data.

Spud to TD was expected to take c. 49 days including an extensive coring programme commencing in the Lower Cretaceous/Upper Jurassic shales and continuing until at least one core had been taken in the water zone. Additional coring was to be carried out on occurence of good hydrocarbon shows in deeper sands.

A further 47 days were allocated for a production testing and abandonment programme.

GEOLOGICAL PROGNOSIS

FORMATION TOPS	LITHOLOGY	DEPTH TVBDF	SEISMIC TOLERANCE
Seabed (Quarternary-Eocene)	Clay, claystones	365	
Eocene	Claystones, sand-stones	875	+/- 10
Palaeocene	Tuffaceous clay-stones, silty clay-stones, Marls.	1185	+/- 30
Cretaceous	Marls and lime-stones	1455	+/- 20
Kimmeridge Clay Formation - thin or absent			
Jurasssi Sandstone Group			
Upper Jurassic	Medium-course, Unconsolidated sandstones	1505	+/- 5
Base gas column		1573	
Middle Jurassic	Very fine, micaceous sandstones, coarser at base.	1595	+/- 20
Mid- Lower Jurassic	Sandstones, clay-stones, coals and marls.	1935	+/- 20
Dunlin Unit Equivalent	Silty/sandy clay-stones, Sandstones at base.	2040	+/- 20
Statfjord Formation	Fine - medium sand-stones with coals at base	2205	+/-30
Triassic Red Beds	Claystones and sandstones	2405	+/-40

TD +/- 2525 m BDF

SUMMARY OF LITHOLOGY

Tertiary

Nordland group	: Buff-light grey sands, loose, frosted, medium to coarse grained, with lithic and shell fragments, pyritic and occasional clays.
Hordaland group	: Light grey soft mudstones, silty and sandy, mainly non-calcareous, occasional limestone stringers, and slightly carbonaceous, and micaceous in parts.
Rogaland group (Balder & Sele formation)	: Light grey mudstones in parts becoming mottled red, pink with white flecks, tuffaceous, slightly silty, becoming less tuffaceous and more sandy towards the bottom of the Balder with the development sands (glauc) in the Sele.
Forties Formation	: Coarse to medium sandstone adn sands, traces lignite and mica,towards the base there is an increase in clay and the calc content, with the development of limestone stringers and mudstones. The limestone buff hard crystalline with an angular break.
Lista "upper" formation	: Mudstone, light grey soft, and non-calc with the occasional development of fine sands and limestone horizons.
Andrews Formation	: Sandstone, grey to light grey, fine to medium grained, mod hard to unconsolidated sands. The sand grains are poorly sorted, sub-rounded and sub-spherical with the development of an argillaceous cement. There are also non calc grey mudstones and traces of white limestones.
Lista "lower" Formation	: Soft grey mudstones, as above, with silt and sands, non calcareous.

Cretaceous

Shetlands group	: A monotonous sequence of light to dark grey calcareous mudstones, with off white chalky limestones, and buff hard dolomite stringers.
Cromer Knoll Group	: Calcareous mudstones as above, but with intercalations of red brown mudstones, also limestones and dolomite stringers.

Jurassic

Kimmeridge Formation	: Dark brown and non calcareous mudstone, carbonaceous, micromic and pyritic.
Brent Group	: Light grey to brown, medium to coarse sandstone, angular to sub-round grains, with argillaceous and patches of calcite cement carbon fragments.
Dunlin Group	: Grey non-calc mudstone and siltstones with some fine grey sandstones, and a trace of microcrystalline white limestone.
Statfjord Group	: Light grey medium to coarse grained sandstone, moderate sorting, glaucanitic, with a white kaolin matrix. Becomes finer towards the base with the development of a hard fissial mudstone.

Triassic

Cormorant Formation	: Alternating grey and red brown mudstone (calc) with minor amounts of chalky white limestone, and poorly sorted sands.

GENERAL WELL SUMMARY

The Semi-submersible drilling rig 'Borgny-Dolphin' (AKER H3) was positioned at the location on the 20/July/1981 and 31/2-6 was spudded on the 21/July/1981.

The position given by Satnav was:

60° 54' 13.57" N

03° 38' 49.43" E

This is 22m on a bearing 193° from proposed location.

A total depth of 1760m was reached on the 22/August/1981.

On the 25/August/1981 the 9 5/8" casing was overpressured during BOP tests necessitating washing-over and fishing the collapsed joint. Since the well's main objectives, had been fulfilled no further drilling was attempted below the 9 5/8" casing point.

11 bits were used

9 cores totalling 127.3m were cut

One RFT was run over the reservoir section

53 CST's were taken (60 shot; 6 lost; 1 empty)

GENERAL WELL DISCUSSION BY INTERVALS

The rig is equipped with two Continental Emsco triplex pumps fitted with 6½" liners. Pressure rating 3981 psi at a maximum of 120spm. Output is 5.158 gal/stroke at 100% efficiency; measured efficiency :95%.

a) 36" phase (368 - 456 m)

Well 31/2-6 was spudded on 21 July 1981. Sea-bed was 368m. The phase began with a 26" OSC 3AJ bit with 3 x 24/32" jets and a 36" hole opener, which drilled to 420m. At this point no further progress could be made : the bit was changed (another 26" OSC 3AJ with 3 x 24/32" jets) and the cutters on the hole opener were replaced, but still no progress was possible.

A 17½" drilling assembly was made up (bit no 3 : OSC 1GJ with 24/32, 16/32, and 14/32" jets) which drilled to 462m. The hole was opened with a 26" H/O and thereafter a 36" H/O was used but could not pass 456m. This was considered enough and the string was pulled out to run 30" casing.

The phase was drilled with sea-water and viscous slugs.

Spud Assembly

26" bit
36" H/O
Bit sub
9½" Monel DC
36" stab
2 x 9½" DC
XO
21 x 8" DC
XO
15 HWDP

Total length : 368.33m

Single shot magnetic surveys :
i) 387m ¼° N80W
ii) 425m ¼° WEST
iii) 457m ¼° S30E

30" Casing :	7 joints of 30" (1" wall) conductor were run. The shoe was set at 448m.
Cementation	The lead slurry consisted of 800 sks class G + 0.36 gal/sk Econolite + gal/sk sea-water at 13.2 ppg. The tail slurry consisted of 777 sks class G + 3% CaCl + 5.15 gal/ sea-water at 15.8 ppg. The slurries were displaced to 6m above the shoe with 37 bbl sea-water.

b) 26" Phase (456 + 820m)

The 30" casing shoe was drilled out to 465m with bit no 4 (17½" DSJ with 3 x 18/32 jets) and a 26" H/O.

17½" pilot hole (465 - 820m)

Without the H/O bit 4 then drilled to 820m. On pulling out the hole was tight but a second trip showed the hole to be in good condition. Schlumberger, however, hit a bridge at 562m and a clean-up bit run followed.

Schlumberger then ran ISF/SONIC/GR/SP
misran FDC/CNL/GR/CAL FOLLOWED BY
FDC/CNL/GR/SP rerun.

On returning to bottom the hole was displaced to sea-water whereupon returns were lost. A 4% gas slug was circulated up and then, 400 bbl 1.13 hi-vis mud were pumped and then open-ended drill-pipe was run in. 460 sks class G cement + 2% CaCl at 15.8 ppg were pumped; the diverter was closed to squeeze the cement.

Bit 5 DSJ drilled cement from 458-497m.. Circulation returned 20% gas. 500bbls 1.15 mud were spotted in the open hole. Open-ended drillpipe was run in to 540m; 50 bbl hi-vis mud were spotted the string was pulled back to 500m.

800 sks class G + 2% CaCl, + 15 PPB LCM mixed with sea-water at 15.8 ppg were displaced to equalise with 22bbl sea-water.

A rerun of bits 5 DSJ (17½"; 3 x 18/32 + 11/32" jets) drilled cement form 443-536m; fell through to 542m and drilled to 595m with sea-water and hi-vis pills.

AVERAGE B.H.A.

Drilling Assembly

17½" bit
bit sub
9½" monel DC
9½" DC
17½" stab
9½" DC
17½" stab
XO
9 x 8" DC
XO
12 HWDP
Dart sub

Total length 229.83m

Single shot magnetic surveys :
i) 562m ¼ S65E
ii) 655m ¼ N30E
iii) 815m ½ N40W

26" UNDERREAMER

The 17½" pilot hole was opened to 26" with an underreamer behind a rerun of bit 5. A BGT showed the hole to be under gauge in several places with intervals up to 100m. The hole was rerreamed twice with a rerun of bit 3 + 26" U/R. The bottom hole assembly was identical to that used in the pilot hole with the addition of the 2.91m underreamer.

Single shot magnetic surveys :
i) 590m 1 N20E
ii) 693m ½ N12E
iii) 814m ½ N40W

The riser was pulled and prior to running 20" casing the hole was displaced with 330 bbl 1.45 sg mud.

20" casing : 36 joints of 20" x 133 lb/ft grade X52 were run, the shoe was set at 800m.

Cementation : 20bbl sea-water were pumped ahead. A lead slurry which consisted of 2560 sks class G + .36 gal/sk Econolite + 10 gal/sk fresh water; 610 bbl mix water at 13.2 ppg. The tail slurry consisted of : 800 sks class G + 2% CaCl + 5.15 gal/sk sea-water, 98 bbl mixwater at 15.8. ppg. Displaced with 63bbl sea-water to 10m above shoe.

550 psi displacement pressure was bled off; float held OK.
Good returns throughout cement job.

c) <u>17½" PHASE (820 - 1485m)</u>

The BOP stack and riser were run and the cement and 20" casing shoe were drilled out with bit 6 (Smith DSJ with 3 x 18/32 + 15/32" jets) to 825m.

(i) pilot hole

Due to the possibility of shallow gas 12¼" bit 7 (SEC S33S with 2 x 14/32 + 18/32" jets) was used to drill this pilot section to 1050m. Gas reached maximum during this section of 7.5% C1 at 1010m. Mud weight throughout the section was 1.26 sg. The hole was tight at 880m during a trip.

(ii) 17½"

A rerun of bit 6 (used also to drill out 20" csg shoe) opened the 12¼" pilot to 17½" down to 1050m. A check trip at this depth showed the hole to be tight at 900m, with max overpull of 125000 lbs, but the hole was clean on the run in and bit 6 drilled new 17½" hole from 1050 - 1303m. At 1256m a 2 stand wiper trip showed overpull of 25-100 000 lbs, but again the hole was clean on the run in. The mud weight, however, was increased to 1.31 sg. During the bit trip at 1301m the hole was tight from 1259-1230m; 1200-1180m; 1003-975m; overpull ranged from 25-110000 lbs.

Bit 8 (17½" Smith DSJ with 18, 18, 22 and 15/32" jets) completed. the phase. On running in with bit 8, the hole was tight and 2 singles were reamed before tagging bottom, whereupon circulation was lost. Pump rate was reduced to 50 spm and mica was added whilst working the kelly (with overpull up : 100 000 and down : 50 000 lbs). Circulation was eventually regained and drilling resumed. Trip gas reached a total from 1303m.

At 1364m gas peaked at 19% total from a background of 2%. At 1485m during the circulation of bottoms up, 60bbl of mud were lost. Mica was added during reduced pump-rate, and losses were eventually reduced. During the trip the hole was tight 5 stands off bottom with 50-100 000 lbs overpull.

The bottom hole assembly was altered (to remove the 17½" stabiliser) and an inspection trip found the hole to be tight at 1499m, but only light reaming to bottom was necessary. A 34% gas peak circulated after stripping. After 2 full circulations, the bit was pulled clean and preparations made for logging.

ELECTRIC LOGGINGS

Sclumberger ran : ISF/SON IC
FDC/CNL
CST - Fired 30; Lost 3 at 1.454.5. 1429.999m

13⅜" casing : 96 joints of 13⅜" casing at 72 lbs/ft, grade L80 were run, the shoe set at 1475.29m.

Cementation

500bbl mud at 1.31 sg were pumped to clean the anulus. This was followed by 25obbl at 1.20 sg. The lead slurry consisted of 1112 sks class G neat with freshwater (.6 Gal/sk) and 5 lb/sk mica at 12.2 ppg. The tail slurry consisted of 395 sks class G neat and freshwater at 15.8 ppg. Displacement was with 531 bbl at 1.32 sg:bump plug with 3000.psi held for 15 minutes.

d) 12¼" PHASE (1485 - 1760m)

Bit 9 (12¼" HTC XIG + 3 X 15/32" jets) tagged cement at 1457m and drilled to 1489m. Here the mud weight was reduced to 1.2sg. A leak off test was then performed returning an equivalent mud gradient of 1.62 sg. However when pumping ceased at 2¼bbl, no leak off to the formation had occured. Also, this figure was derived not from the maximum surface pressure reached but from the stabilised value. It is therefore a conservative estimate of the fracture gradient at the shoe.

Maximum gas in return with the 1.20 sg mud was 5.5%. Bit 9 was then pulled to run a junk basket as a prelude to coring.

On resuming drilling at 1489m, 26% trip gas was returned. Circulations for geological samples occured at 1497 and 1501m.

Maximum gas returned was 24%. At 1504.8m due to the high percentage of sand in the sample, it was decided to core.

CORING SECTION (1504.8 - 1632.1m)

9 cores in fibre glass sleeves were taken. For the first run a 10.77m core barrel was used; for the second and all subsequent runs, a double (19.91m) barrel was used.

2 main bottom hole assemblies were used; the BHA used for core 2 was the same as that used for core 1 except for a double core barrel and a 6½" DC was added to the assembly.

BHA core 1	BHA cores 3-9
Core head	Core Head
Core barrel (10.77m)	Core barrel (19.91m)
Sub	Sub
12¼" Stab	6½" DC
14 x 8" DC	8½" Stab
6½" Jar	6½" DC
6½" Jar	8½" Jab
2 x 8" DC	7 x 6½" DC
XO	6½ Jar
15 x HWDP	6½" Jar
Sub	2 x 6½" DC
	15 x HWDP
	Sub
total Length : 325.32m	Total Length : 272.84m

3 coreheads were used to drill the section. Nos 1 and 3 were both diamond CB 303's. No 2 was a statapax CB 502 using industrial diamonds with a course cutting action. This corehead cut quickly (up to 5 min/m) where the formation was friable but almost halted in well cemented formations. In consequence cores of only 4.8 and 6.4 were obtained with this corehead.

Core Nos. 1 and 2 both had to be worked free on pulling out. Maximum overpull was 130 000 lbs (core 1) and 140 000 lbs core 2). No overpull was recorded when the BHA was changed for subsequent runs.

The core barrel jammed on run 8. This was indicated by a rapid 200 psi pressure loss with decrease in both torque and ROP.

It was pulled having cored 15.9m.

From 1564 - 1567m there were traces of direct uv fluorescence.

From 1567 - 1579m this increased to a moderately good pale yellow colour, and from 1579 - 1599 there was a good yellow to pale blue direct fluorescence. Below 1599m there was no fluorescence.

Cut (solvent) fluorescence was weak to moderate from 1557 - 1654m. From 1564 - 1571m there was good milky white cut and from 1571 - 1578m the cut became slow with a green-brown colour. Below 1578m the colour was milky with a yellow-brown stream. No cut was observed below 1599m.

On inspection of Schlumberger logs, the top of gas was estimated to be 1492m; the gas-oil contact at 1572m, and the oil-water contact at 1582m.

The only significant trip gas occured at 1504m (24%), and at 1532m (18%). Maximum drilled gas during coring was 3% at 1540m. Levels remained well below 1% in the oil and water phases.

A tabulated summary of thecoring section is given below.

<u>BIT 10</u> (SEC S44 + 14,14,18/32" jets) was used to open the cored section to 12¼". Trip gas at 1504m was 32%, and gas levels remained around 10% to 1570m, where they fell to below 1%. Bit 10 drilled 25m of new hole to 1657m. The bit was 3/8" under gauge.

<u>BIT 11</u> (Smith FVH + 3 x 15/32" jets) finished the phase to 1760m. No hole problems were encountered.

SCHLUMBERGER LOGS

Ran and logged ISF/Sonic, FDC/CNL; MSFL/DLL; HDT. RFT; CST - recovered 27, lost 3 at 1488; 1489.5; and 1497m; CBL.

9⅝" CASING

116 joints of 9⅝" x 47 lbs/ft grade VAM N80/L80 were run and the shoe set at 1752m.

CORE	CORE HEAD	IDEN-TITY	INTERVAL		CORED (M)	RECOVERY %	AVERAGE DRILLING PARAMETERS			COMMENTS	LITHOLOGY
			IN	OUT			R.O.P. (MIN/M)	W.O.B. K lbs	BOTTOM HOURS		
1	1	CB 303	1504.4	1514.0	9.6	98	20.8	15.8	3.2	Work Pipe to free barrel when pooh (max ovp 130 k lbs)	SST. f - med grn. fri-hd. hd arg cmt.
2	1RR	CB 303	1514.0	1532.5	18.5	100	26.4	16.9	8.1	Work pipe to free Barrel when pooh (Max ovp 140 k lbs	Sst : f - crs grns, fri mod cmt
3	1RR2	CB 303	1532.5	1551.0	18.4	99.5	20.8	19.6	6.17		Sst. f -crsgrns.fri, mod cem
4	2	CB 502 (STPX)	1551.0	1556.0	5.0	96	17.8	3.8	1.2		Sst : f-very crs grns. fri, mod cem; occ rock frag
5	1RR3	CB 303	1556.0	1576.1	18.5	99	45.7	16.8	13.4	Depth correction made here	Sst. f - crs grns, fri, mod cmt, with shell frag.
6	2RR	CB 502 (STPX)	1576.1	1583.9	7.8	80	43.9	7.2	5.7		Sst. f - crs grs, hard with hard cmt.
7	3	CB 303	1583.9	1602.8	18.9	97	24.3	18.1	7.4		Sst. f - crs grns, fri to mod hard, calc cmt non cmt
8	3RR	CB303	1602.8	1618.7	15.9	99	30.3	18.0	8.0	200 psi pres. loss + drop in torque d R.O.P. core barrel jammed	SSt, (1602-1607) silt to f grns. cons hard. (1607-1618) f - crs grns, cons hard.
9	3RR2	CB303	1618.7	1632.1	13.4	100	28.8	17.7	6.25		Sst. f - crs, fri - mod hr cons, calc cmt.

N.B The CB 303's were run with RPM 90 - 100 and a flow rate of 245 gallons/Min.
The CB 502 was run with RPM 105 and a flow rate of 290 gallons/min.

CEMENTATION

164 sks class G mixed with fresh water containing cfr-2; econolite and hlx-c2481 as scavanger slurry at 13.5 ppg. Followed by 620 sks class G tail slurry mixed with fresh-water containing cfr-2, econolite and hlx-c248 at 15.4ppg.

The cement was displaced with 21 bbl spacer followed by 327 bbl mud at 1.18 sg. Bumped plug with 4000psi for 15 minutes - no back flow.

CASING PROBLEMS

During pressure testing of the BOP, it was discovered that due to the seal not being properly set, the 9⅝" x 13⅜" anulus had been overpressured (5600 psi applied below pipe-rams and collapse pressure of 9⅝" casing = 4750 psi).

On running in the hole a restriction was met at 771m; the restriction was later indicated as being less than 2". The casing was cut at 760m and the undamaged casing retrieved, leaving the obstruction at 768m.

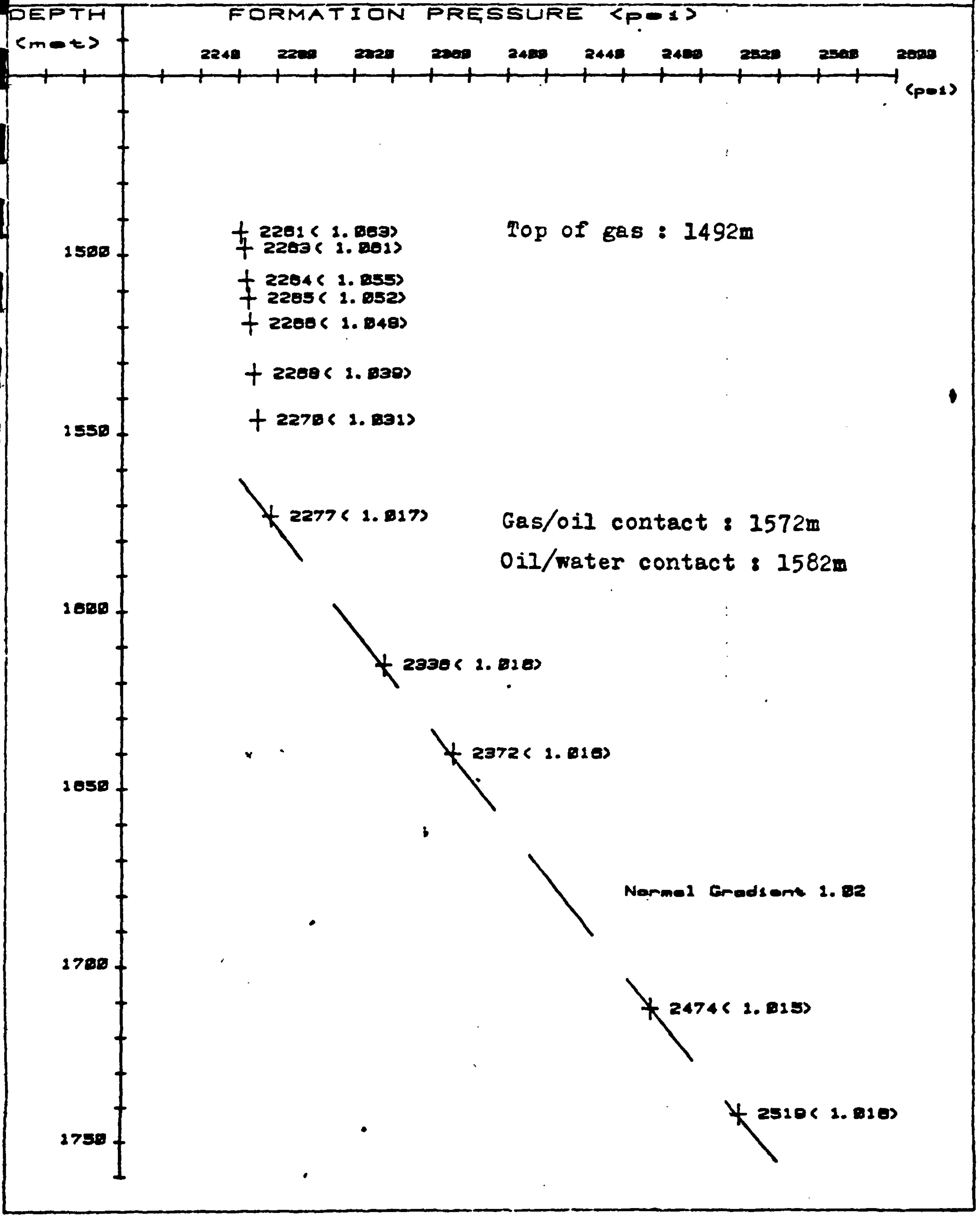
After four days of milling and washing over, a flattened, burst joint of casing was succesfully fished with two undamaged joints of 9⅝" casing connected below it. This left the top of the 9⅝" casing at c.804m.

The exposed 13⅜" casing was scrapped; Schlumberger ran a CBL which showed poor bonding behind the 9⅝" casing, but a RTTS packer was run and set twice to test for leaks between the 9⅝" and 13⅜" casings and there was none. Preparations were then made for production testing.

GEOSERVICES

SHELL 31/2-6

REPEAT FORMATION TEST REPORT



D'EXPONENT OVERPRESSURE SURVEY

The d'exponent trend line was established in the top hole section with two coupled depth and dcn value points viz.

at zero metres dcn = 0.82; at 1900m dcn = 0.93.

This gives trend-line regression coefficients

a = .00000877 and b = -.08619.

The trend required shifting below the 20" casing shoe using the couples : at zero metres, dcn = 0.75, at 1900m dcn = 0.86. This gives coefficients a = .000009535 and b = -.12490.

Another shift was required during coring, using the couples : at zero meteres, dcn = 1.75; at 1900m dcn = 1.86. This gives coefficents a . 000004247 and b = .243.

Whilst drilling with bit 6RR, a steady decrease in d'exponent values is seen beginning at 1200m and continuing untilc.1250m, the d'exponent remaining well left of the trend line until 1302m. Many things pointed to the presence of a short undercompacted shale section in these Palaeocene claystones. At 1256m, mud weight was incresed to control caving; overpull during tripping increased dramatically at 1303m; trip gas also increased considerably at this depth.

The Palaeocene claystones were occasionally silty and this normally gives a negative shift in d'exponent values, but this depends very much on the nature of the host rock as can be seen below 1400m. The occurence of under-compaction in the Palaeocene claystones is clearly a debatable subject, but due to the observations while drilling, it was considered preferable to allow a brief rise in predicted formation pressure (to a maximum of 1.18) during the 17½" phase. (see d'exp plots).

OVERBURDEN AND FRACTURE GRADIENT DETERMINATION

To estimate the local fracture gradient, appropriate values of vertical (overburden) and horizontal stress coefficients must be found.

The variation of overburden with depth may be approximated by the third order polynomial :

$S = a\ln^2 \text{depth} + b\ln \text{depth} + c$ where
S = overburden gradient; a, b, c are coefficients of regression.

The coefficients used during drilling were:

a = 0.01304
b = -0.17314
c = 1.43350

These are typical values for the Gulf Coast area.

FDC and Sonic Log Data (from 31/2-4 and 31/2-6) was then used, and from the regression data of each batch the coefficients were evolved. Four regression curves were plotted (Fig. 1); curves 2, 3, 4 and 5 show the influence of the water column. The coefficients derived from the FDC date (31/2-6) curve 4 are:

a = -0.05119
b = 1.00822
c = -4.10036

and these values were used in the calculation of Poisson's ratio, *"mu"* and in the subsequent rerun of the d'exponent at the end of the well.

The horizontal stress compnent of the fracture gradient may be estimated by the second order polynomial :

$$K = \frac{\text{"mu"}}{1 = \text{"mu"}}$$

$$\ln K = a \ln \text{depth} + b$$

$$\text{"mu"} = \frac{FSG - FPG}{(FSG = S = 2FPG)}$$

Where FSG = Formation strength gradient estimated from leak-off test

FPG = Formation pore pressure
"nu"= Poisson's Ratio

a and b are coefficients derived form a best fit regression curve of the variation of Poisson's ratio with depth.

The Poisson coefficients used during drilling were

a = 0.277
b = 2.977

However, these gave a low fracture gradient and therefore the local LOT data was used to calculate the coefficients for Poisson's ratio.

These were also found to be unsuitable as they gave a negative regression (see Fig. 2 curve (3)) and thus a negative fracture gradient curve.

Coefficients were therfore chosen to fit the fracture gradient to that estimated for this area. These were:

a = 0.006561
b = -0.088452

See Fig. 2 Curve (2).

The printed table reproduces a fracture gradient curve using the above local values for Overburden and Poisson and this is plotted along with the Overburden curves in Fig 1.

FRACTURE GRADIENT   SHELL 31/2-6

Poisson's	Overburden
A: 0.0065	A:-0.0512
B:-0.0885	B: 1.0082
	C:-4.1004

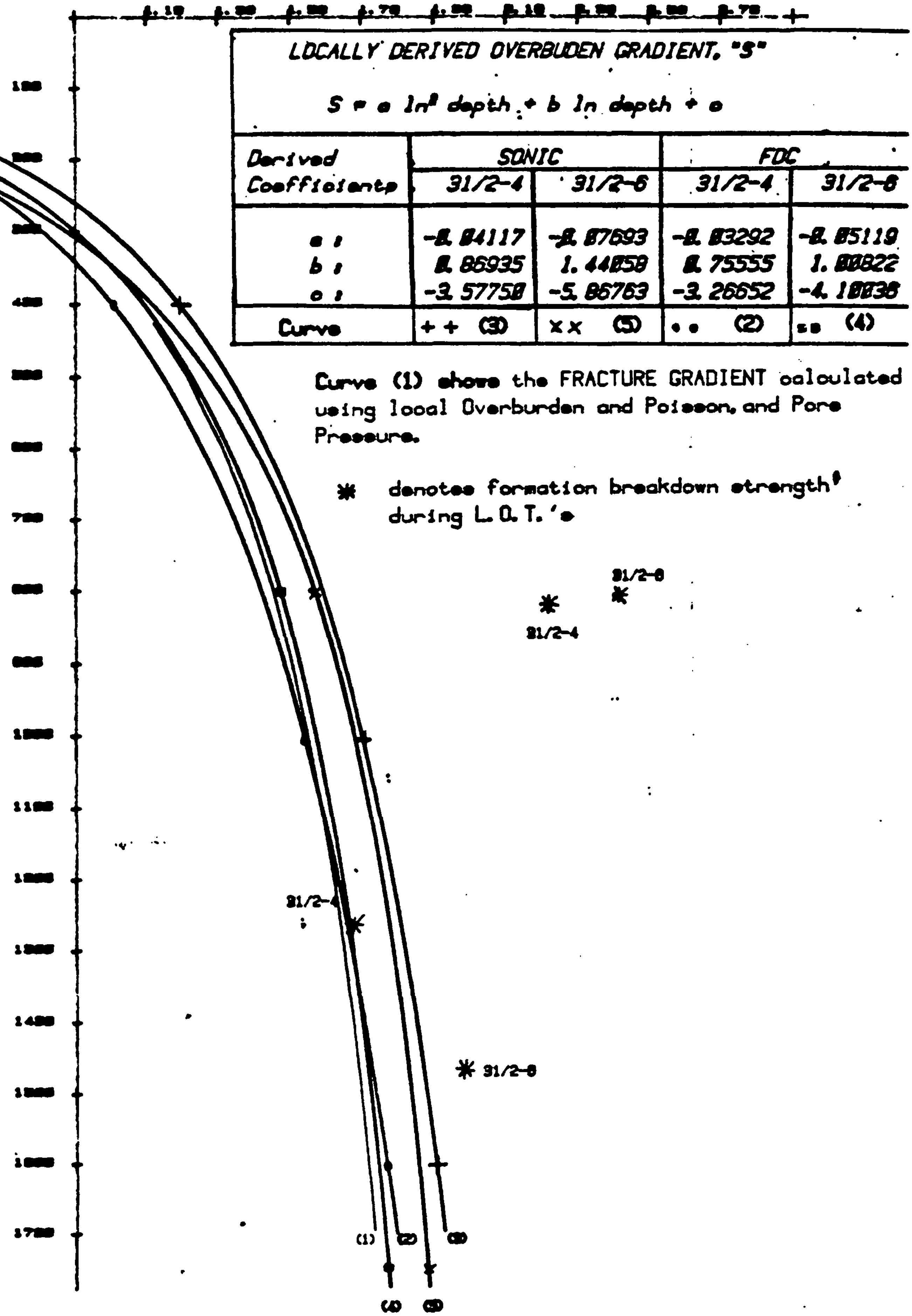
DEPTH	K	S	Pf	frac
400	0.959	1.150	1.030	1.145
500	0.960	1.284	1.030	1.274
600	0.962	1.385	1.030	1.372
700	0.963	1.465	1.030	1.448
800	0.963	1.529	1.030	1.511
900	0.964	1.582	1.030	1.562
1000	0.965	1.627	1.030	1.606
1100	0.965	1.665	1.030	1.643
1200	0.966	1.698	1.030	1.676
1300	0.966	1.727	1.030	1.704
1400	0.967	1.753	1.030	1.729
1494	0.967	1.774	1.063	1.751
1498	0.967	1.775	1.061	1.751
1507	0.967	1.777	1.055	1.753
1512	0.967	1.778	1.052	1.754
1519	0.967	1.779	1.048	1.755
1533	0.967	1.782	1.039	1.758
1546	0.967	1.785	1.031	1.760
1573	0.968	1.790	1.017	1.765
1615	0.968	1.798	1.016	1.773
1640	0.968	1.802	1.016	1.777
1712	0.968	1.815	1.015	1.789
1742	0.968	1.820	1.016	1.794

The above table reproduces a fracture gradient curve using locally derived coefficients for the Overburden gradient,S (FDC 31/2-6). The coefficients for the horizontal stress component,"nu",were chosen to fit the fracture gradient to that estimated for this area.

Fig. 1

SHELL 31/2-6

OVERBURDEN GRADIENT



LOCALLY DERIVED OVERBUDEN GRADIENT, "S"

S = a ln² depth + b ln depth + c

Derived Coefficients	SONIC 31/2-4	SONIC 31/2-6	FDC 31/2-4	FDC 31/2-6
a :	-0.04117	-0.07693	-0.03292	-0.05119
b :	0.86935	1.44058	0.75555	1.00822
c :	-3.57750	-5.86763	-3.26652	-4.18038
Curve	+ + (3)	x x (5)	• • (2)	▪▪ (4)

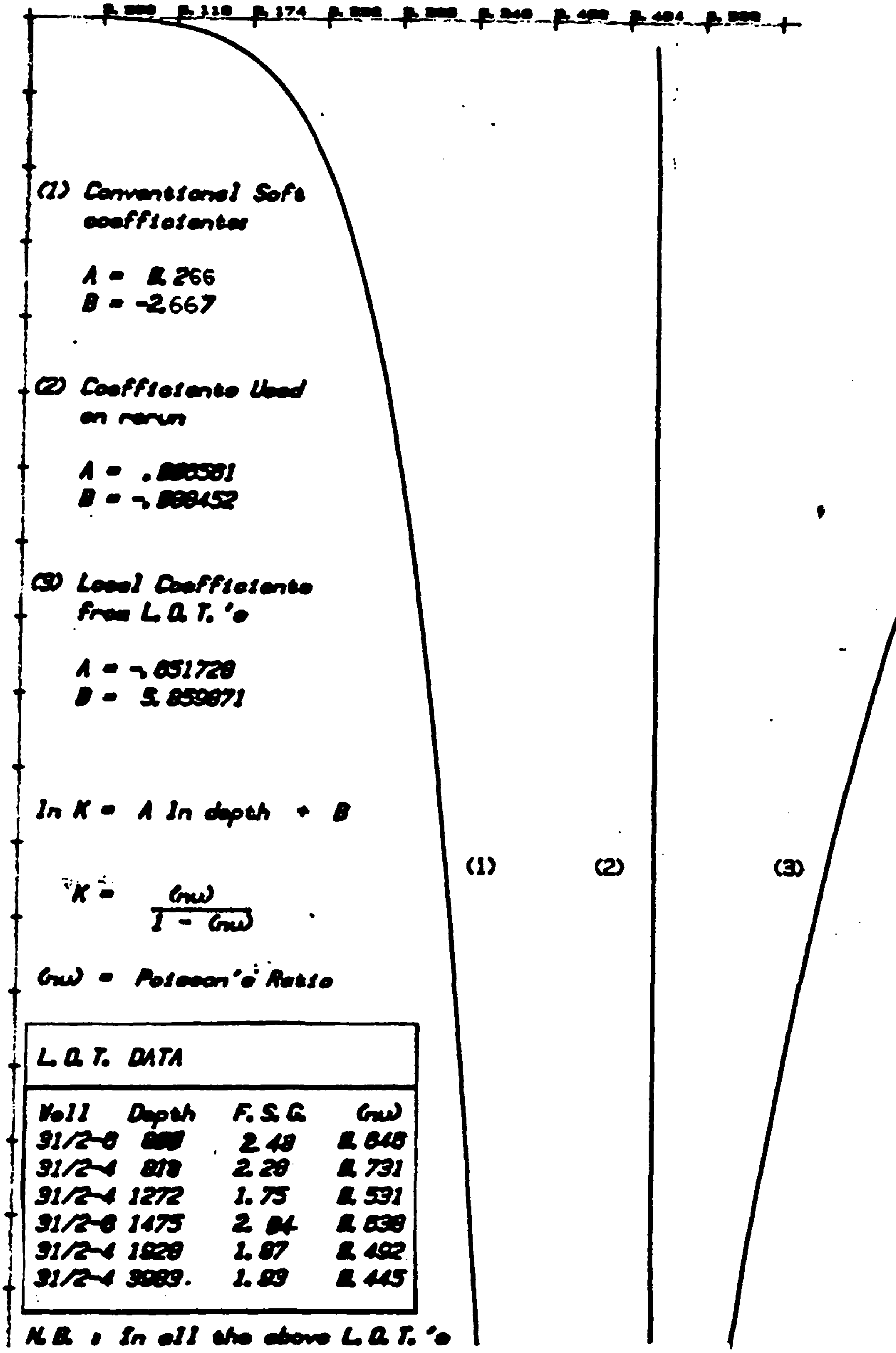
Curve (1) shows the FRACTURE GRADIENT calculated using local Overburden and Poisson, and Pore Pressure.

✱ denotes formation breakdown strength during L.O.T.'s

Fig. 2

SHELL 31/2-6

POISSON RATIO CNLD



(1) Conventional Soft coefficients

A = 0.266
B = -2.667

(2) Coefficients Used on rerun

A = .000581
B = -.000452

(3) Local Coefficients from L.O.T.'s

A = -.051728
B = 5.859871

$\ln K = A \ln \text{depth} + B$

$K = \frac{(nu)}{1 - (nu)}$

(nu) = Poisson's Ratio

L.O.T. DATA			
Well	Depth	F.S.G.	(nu)
31/2-6	[illegible]	2.48	0.648
31/2-4	818	2.28	0.731
31/2-4	1272	1.75	0.531
31/2-6	1475	2.04	0.638
31/2-4	1928	1.87	0.492
31/2-4	3083.	1.93	0.445

N.B. : In all the above L.O.T.'s

1) Formation Strength Gradient (F.S.G.) was calculated using the maximum pressure reached.

2) a locally derived overburden gradient (see FDC 31/2-6) was used in the calculation of (nu).

DEVIATION

The vertical depth, hole co-ordinates at the corresponding depth and dog-leg in degrees per 30 metres are computed using the "radius of curvature" method when the radius of curvature is not too large (i.e. if drift is greater than 1.5°) and the "average angle" method otherwise. This is to avoid large errors when drift angles and nearing angles are equal or nearly equal for two consecutive survey points (i.e. in those cases where the radius of curvature is infinite or at least extremely large).

BIT PERFORMANCE

As well as the bit report printed out at the end of each bit run, a cost performance graph is plotted to enable a quick look interpretation of the bit's actual performance down hole.

Two curves are plotted for cost versus depth, one standard and including the total time that the bit was in the hole-drilling plus connections. The other based on the actual on-bottom rotating hours only.

The rate of penetration is also plotted to determine whether a decrease in the drilling rate is due to bit wear of formation change. The minimum cost point for each curve is determined and noted with the time and depth at which it occurred.

The data is obtained directly from the on-line data tapes with the bit cost/metre being computed according to the formula

$$C = \frac{RC\ (TT = RT) + BC}{M}$$

Where : C : cost per metre in $ US

BC: bit cost in $ US

RC: rig cost overall in $ US/hour
TT: average time for the round trip at drilling depth in decimalised hours

RT: rotary time or elapsed time in decimalised hours

M : metrage drilled after elapsed time in metres

The cost per metre versus time follows a curve passing through a minimum. The assumed cost of the rig has been taken as $2708/hour.

D-EXPONENT

Used in the Geoservices development of the d-exponent which computes a normalised rate of penetration to highlight anomalies in formation compaction.

An expression may be found for a compaction trend in normally p ressured shales. Negative departures from this trend will indicate undercompaction and potential overpressures.

EQUATIONS

The original equation for d-exponent was developed by Jordan and Shirley in 1966, mud weight correction applied by Rehm and McClendon and bit wear/type correction applied by Geoservices.

$$dcs = \frac{\log \frac{a^{p}\,ROP}{60\ RPM}}{\log \frac{12\ WOB}{10^{6}\ Dh}} \times \frac{H}{ECD}$$

Where ECD = the equivalent circulating density and a^{p} a bit wear correction

$$a = 93T^{2} + 6T+1$$

$$T = x \quad \frac{.31FBW^{2} + 3FBW + 1}{.31\ x^{2} + 3x + 1}$$

x = FBW ((TD - 1D)/L)

p = a parameter of bit type (diamond to soft mill tooth

TD total depth

L = run length

FBW= final bit wear (n/8)

The dcs trend line may be expressed as a straight line with an equation such as

$$\log (dx) = a\ 2+6$$

The trend may be given manually through the CRT keyboard or the computer may find it's own trend within predetermined limits over a particular interval.

When the observed dcs is lower than the trend:

$$PF + S = (S-H) \left(\frac{dcs}{\overline{ndcs}}\right)^{1.2}$$

Where S ≐ overburden gradient

Equivalent circulating density is the effective pressure of the mud in circulation, taking into account the back pressure of the mud in the annulus.