W 11

Seismograph Service (England) Limited

AIRGUN WELL VELOCITY SURVEY AND CALIBRATED LOG DATA

FROM DRESSER ATLAS ACOUSTILOGS

COMPANY STATOIL

WELL 15/9-18

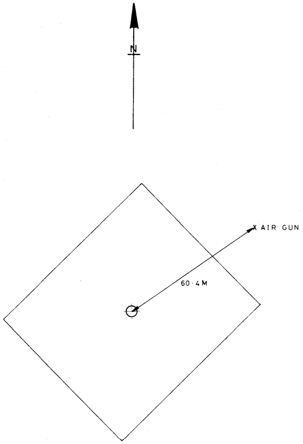
FIELD SIGMA

COUNTRY NORWAY NORTH SEA

DATE OF LOGGING 19·12·83 28·12·83 17·1·84 4·2·84 20·2·84 ACOUSTIC LOGS.

DATE OF WELL VELOCITY SURVEY 21·2·84

M5580



WELL: 15/9-18
RIG NAME: D.S. BERGEN
RIG DIAGRAM

TRACE:
1
2-4
5-7
8
9
10
11
12

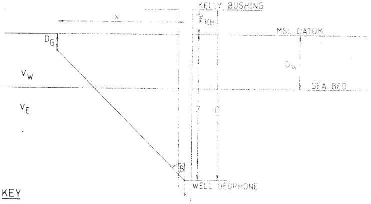
WELL: 15/9-18

MONITOR RECORD FORMAT:

FUNCTION:

Timer Track
Well Geophone filtered
Well Geophone unfiltered
Read After Write Well Geophone
Gun Hydrophone
R.A.W. Gun Hydrophone
TB and R.A.W. TB
R.A.W. Timer Track

SCHEMATIC CROSS-SECTION



KEY

KB - Kelly Bushing
D - Depth of Well Geophone below KB
E_{KB} - Elevation of KB above datum
Z - Depth of Well Geophone below datum
D_G - Depth of Gun below M S L
H - Distance between Gun and Gun Hydrophone
D_W - Depth of Water
V_W - Water Velocity
V_E - Elevation Velocity
X - Horizontal distance from Well to Gun
β - Incident angle at Well Geophone levels
T - Observed travel-time between Gun Hydrophone and Well Geophone
T_V - Travel-time from Gun to Well Geophone corrected to the vertical, $(T + \frac{H}{V_W}) \cos \beta$
T_E - Travel-time correction from Gun to datum
T_C - $T_V + T_E$
ΔZ - Interval distance
ΔT_C - Interval travel-time
V_A - Z/T_C (Average velocity)
V_I - $\Delta Z/\Delta T_C$ (Interval velocity)

COMPANY: STATOIL
WELL: 15/9-18
AIRGUN COMPUTATION

RECORD NO	D'	D	Z
	M	M	M
91	750.0	750.0	727.0
90	867.0	867.0	844.0
89	900.0	900.0	877.0
88	1050.0	1050.0	1027.0
87	1200.0	1200.0	1177.0
86	1230.0	1230.0	1207.0
85	1255.0	1255.0	1232.0
84	1260.0	1260.0	1237.0
83	1290.0	1290.0	1267.0
82	1320.0	1320.0	1297.0
81	1350.0	1350.0	1327.0
80	1380.0	1380.0	1357.0
79	1410.0	1410.0	1387.0
78	1440.0	1440.0	1417.0

SEISMOGRAPH SERVICE (ENGLAND) LTD.
WELL SURVEY DIVISION

E_{KB} = 23.0M
V_W = 1478M/S

KB= 23.0M AMSL
E_D = MSL

GUN DEPTH 10.0M
GUN HYDROPHONE DEPTH 13.0M
GUN OFFSET 60.4M

X	T	T_V	T_E	T_C	AVERAGE VELOCITY	INTERVAL DEPTH	INTERVAL TIME	INTERVAL VELOCITY
M	S	S	S	S	M/S	M	S	M/S
60.4	0.3965	0.3971	0.0068	0.4039	1800			
60.4	0.4524	0.4532	0.0068	0.4600	1835			
						150.0	0.0724	2073
60.4	0.4686	0.4695	0.0068	0.4763	1841			
						150.0	0.0726	2067
60.4	0.5410	0.5420	0.0068	0.5488	1871			
						150.0	0.0694	2160
60.4	0.6103	0.6115	0.0068	0.6183	1904			
60.4	0.6250	0.6262	0.0068	0.6330	1907			
60.4	0.6380 *	0.6392	0.0068	0.6460	1907			
60.4	0.6392	0.6404	0.0068	0.6472	1911			
						90.0	0.0433	2080
60.4	0.6535	0.6547	0.0068	0.6615	1915			
60.4	0.6680	0.6693	0.0068	0.6761	1918			
60.4	0.6820	0.6833	0.0068	0.6901	1923			
						90.0	0.0440	2048
60.4	0.6974	0.6987	0.0068	0.7055	1923			
60.4	0.7119	0.7132	0.0068	0.7200	1926			
60.4	0.7252	0.7265	0.0068	0.7333	1932			

RECORD NO	D*	D	Z
	M	M	M
77	1470.0	1470.0	1447.0
76	1500.0	1500.0	1477.0
75	1530.0	1530.0	1507.0
74	1560.0	1560.0	1537.0
73	1590.0	1590.0	1567.0
72	1620.0	1620.0	1597.0
71	1650.0	1650.0	1627.0
70	1680.0	1680.0	1657.0
69	1710.0	1710.0	1687.0
68	1740.0	1740.0	1717.0
67	1770.0	1770.0	1747.0
66	1800.0	1800.0	1777.0
65	1830.0	1830.0	1807.0
64	1860.0	1860.0	1837.0
63	1890.0	1890.0	1867.0
62	1920.0	1920.0	1897.0
61	1950.0	1950.0	1927.0
60	1980.0	1980.0	1957.0

X	T	T$_V$	T$_E$	T$_C$	AVERAGE VELOCITY	INTERVAL DEPTH	INTERVAL TIME	INTERVAL VELOCITY
M	S	S	S	S	M/S	M	S	M/S
						90.0	0.0437	2057
60.4	0.7411	0.7424	0.0068	0.7492	1931			
60.4	0.7551	0.7565	0.0068	0.7633	1935			
60.4	0.7695	0.7709	0.0068	0.7777	1938			
						90.0	0.0427	2106
60.4	0.7838	0.7852	0.0068	0.7920	1941			
60.4	0.7977	0.7991	0.0068	0.8059	1944			
60.4	0.8138	0.8152	0.0068	0.8220	1943			
						90.0	0.0437	2058
60.4	0.8275	0.8289	0.0068	0.8357	1947			
60.4	0.8400	0.8414	0.0068	0.8482	1953			
60.4	0.8542	0.8556	0.0068	0.8624	1956			
						90.0	0.0415	2167
60.4	0.8690	0.8705	0.0068	0.8773	1957			
60.4	0.8838	0.8853	0.0068	0.8921	1958			
60.4	0.8958	0.8973	0.0068	0.9041	1966			
						90.0	0.0407	2210
60.4	0.9097	0.9112	0.0068	0.9180	1968			
60.4	0.9243	0.9258	0.0068	0.9326	1970			
60.4	0.9383	0.9398	0.0068	0.9466	1972			
						90.0	0.0417	2157
60.4	0.9514	0.9529	0.0068	0.9597	1977			
60.4	0.9644	0.9659	0.0068	0.9727	1981			
60.4	0.9780	0.9795	0.0068	0.9863	1984			

RECORD NO	D*	D	Z	X	T
	M	M	M	M	S
59	2010.0	2010.0	1987.0	60.4	0.9919
58	2040.0	2040.0	2017.0	60.4	1.0049
57	2070.0	2070.0	2047.0	60.4	1.0193
56	2100.0	2100.0	2077.0	60.4	1.0305
55	2130.0	2130.0	2107.0	60.4	1.0433
54	2160.0	2160.0	2137.0	60.4	1.0582
53	2190.0	2190.0	2167.0	60.4	1.0721
52	2220.0	2220.0	2197.0	60.4	1.0838
51	2250.0	2250.0	2227.0	60.4	1.0963
50	2280.0	2280.0	2257.0	60.4	1.1098
49	2310.0	2310.0	2287.0	60.4	1.1219
48	2340.0	2340.0	2317.0	60.4	1.1328
47	2370.0	2370.0	2347.0	60.4	1.1437
46	2400.0	2400.0	2377.0	60.4	1.1554
45	2430.0	2430.0	2407.0	60.4	1.1691
44	2460.0	2460.0	2437.0	60.4	1.1783
43	2490.0	2490.0	2467.0	60.4	1.1882
42	2520.0	2520.0	2497.0	60.4	1.1971

RECORD NO	D*	D	Z	X	T	T_V	T_E	T_C	AVERAGE VELOCITY	INTERVAL DEPTH	INTERVAL TIME	INTERVAL VELOCITY
	M	M	M	M	S	S	S	S	M/S	M	S	M/S
										90.0	0.0405	2221
41	2550.0	2550.0	2527.0	60.4	1.2077	0.9934	0.0068	1.0002	1987			
40	2580.0	2580.0	2557.0	60.4	1.2161	1.0064	0.0068	1.0132	1991			
39	2610.0	2610.0	2587.0	60.4	1.2248	1.0209	0.0068	1.0277	1992			
										90.0	0.0386	2330
38	2640.0	2640.0	2617.0	60.4	1.2356	1.0321	0.0068	1.0389	1999			
37	2670.0	2670.0	2647.0	60.4	1.2451	1.0449	0.0068	1.0517	2003			
36	2700.0	2700.0	2677.0	60.4	1.2533	1.0598	0.0068	1.0666	2004			
										90.0	0.0416	2162
35	2730.0	2730.0	2707.0	60.4	1.2620	1.0737	0.0068	1.0805	2006			
34	2760.0	2760.0	2737.0	60.4	1.2674	1.0854	0.0068	1.0922	2012			
33	2790.0	2790.0	2767.0	60.4	1.2727	1.0979	0.0068	1.1047	2016			
										90.0	0.0377	2386
32	2820.0	2820.0	2797.0	60.4	1.2805	1.1114	0.0068	1.1182	2018			
31	2850.0	2850.0	2827.0	60.4	1.2863	1.1235	0.0068	1.1303	2023			
30	2880.0	2880.0	2857.0	60.4	1.2930	1.1344	0.0068	1.1412	2030			
										90.0	0.0339	2653
29	2910.0	2910.0	2887.0	60.4	1.2997	1.1453	0.0068	1.1521	2037			
28	2940.0	2940.0	2917.0	60.4	1.3072	1.1570	0.0068	1.1638	2042			
27	2970.0	2970.0	2947.0	60.4	1.3142	1.1707	0.0068	1.1775	2044			
										90.0	0.0346	2600
26	3000.0	3000.0	2977.0	60.4	1.3232	1.1799	0.0068	1.1867	2054			
25	3030.0	3030.0	3007.0	60.4	1.3297	1.1898	0.0068	1.1966	2062			
24	3060.0	3060.0	3037.0	60.4	1.3390	1.1987	0.0068	1.2055	2071			

RECORD NO	D'	D	Z	X		T_U	T_E	T_C	AVERAGE VELOCITY	INTERVAL DEPTH	INTERVAL TIME	INTERVAL VELOCITY
	M	M	M	M		S	S	S	M/S	M	S	M/S
										90.0	0.0294	3059
23	3090.0	3090.0	3067.0	60.4		1.2094	0.0068	1.2162	2078			
22	3120.0	3120.0	3097.0	60.4		1.2178	0.0068	1.2246	2088			
21	3150.0	3150.0	3127.0	60.4		1.2265	0.0068	1.2333	2098			
										90.0	0.0279	3224
20	3180.0	3180.0	3157.0	60.4		1.2373	0.0068	1.2441	2104			
19	3210.0	3210.0	3187.0	60.4		1.2468	0.0068	1.2536	2112			
18	3240.0	3240.0	3217.0	60.4		1.2550	0.0068	1.2618	2122			
										90.0	0.0264	3407
17	3270.0	3270.0	3247.0	60.4		1.2637	0.0068	1.2705	2131			
16	3300.0	3300.0	3277.0	60.4		1.2691	0.0068	1.2759	2145			
15	3330.0	3330.0	3307.0	60.4		1.2744	0.0068	1.2812	2160			
										90.0	0.0185	4861
14	3360.0	3360.0	3337.0	60.4		1.2822	0.0068	1.2890	2170			
13	3390.0	3390.0	3367.0	60.4		1.2880	0.0068	1.2948	2183			
12	3420.0	3420.0	3397.0	60.4		1.2947	0.0068	1.3015	2195			
										90.0	0.0192	4684
11	3450.0	3450.0	3427.0	60.4		1.3014	0.0068	1.3082	2207			
10	3480.0	3480.0	3457.0	60.4		1.3089	0.0068	1.3157	2217			
9	3510.0	3510.0	3487.0	60.4		1.3159	0.0068	1.3227	2228			
										90.0	0.0235	3828
8	3540.0	3540.0	3517.0	60.4		1.3249	0.0068	1.3317	2235			
7	3570.0	3570.0	3547.0	60.4		1.3314	0.0068	1.3382	2247			
6	3600.0	3600.0	3577.0	60.4	*	1.3407	0.0068	1.3475	2254			

T	T_V	T_E	T_C	AVERAGE VELOCITY	INTERVAL DEPTH	INTERVAL TIME	INTERVAL VELOCITY
S	S	S	S	M/S	M	S	M/S
					90.0	0.0258	3487
1.3490 *	1.3507	0.0068	1.3575	2259			
1.3598	1.3605	0.0068	1.3673	2265			
1.3701	1.3718	0.0068	1.3786	2268			
					90.0	0.0320	2812
1.3810	1.3827	0.0068	1.3895	2272			
1.3918	1.3935	0.0068	1.4003	2276			
1.4010	1.4028	0.0068	1.4096	2282			
					90.0	0.0282	3190
1.4092	1.4110	0.0068	1.4178	2290			
1.4198	1.4216	0.0068	1.4284	2294			
1.4267	1.4285	0.0068	1.4353	2304			
					90.0	0.0262	3434
1.4354	1.4372	0.0068	1.4440	2311			
1.4457	1.4475	0.0068	1.4543	2315			
1.4541	1.4559	0.0068	1.4627	2322			
					90.0	0.0256	3514
1.4610	1.4628	0.0068	1.4696	2332			
1.4694	1.4712	0.0068	1.4780	2339			
1.4773	1.4791	0.0068	1.4859	2347			
					90.0	0.0234	3945
1.4844	1.4862	0.0068	1.4930	2356			
1.4906	1.4924	0.0068	1.4992	2366			
1.4976	1.4994	0.0068	1.5062	2375			

RECORD NO	D*	D	Z
	M	M	M
5	3620.0	3620.0	3597.0

T IS THE TIME MEASURED FROM THE FIRS
USING AN AUTOMATED TRACE ALIGNMENT PR

A TIME CORRECTION FOR THE DISTANCE FR

TV IS THE TIME FROM THE GUN TO THE WE

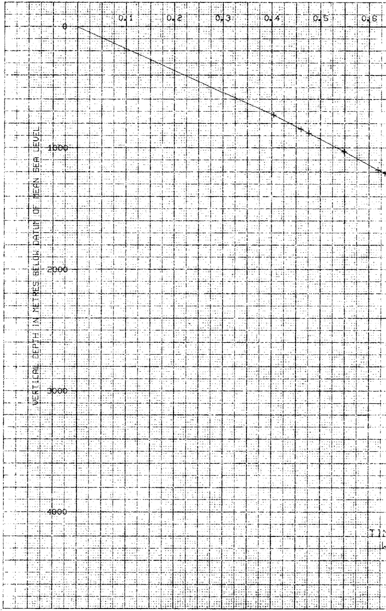
$TE = \frac{\text{GUN DEPTH}}{\text{VW}}$

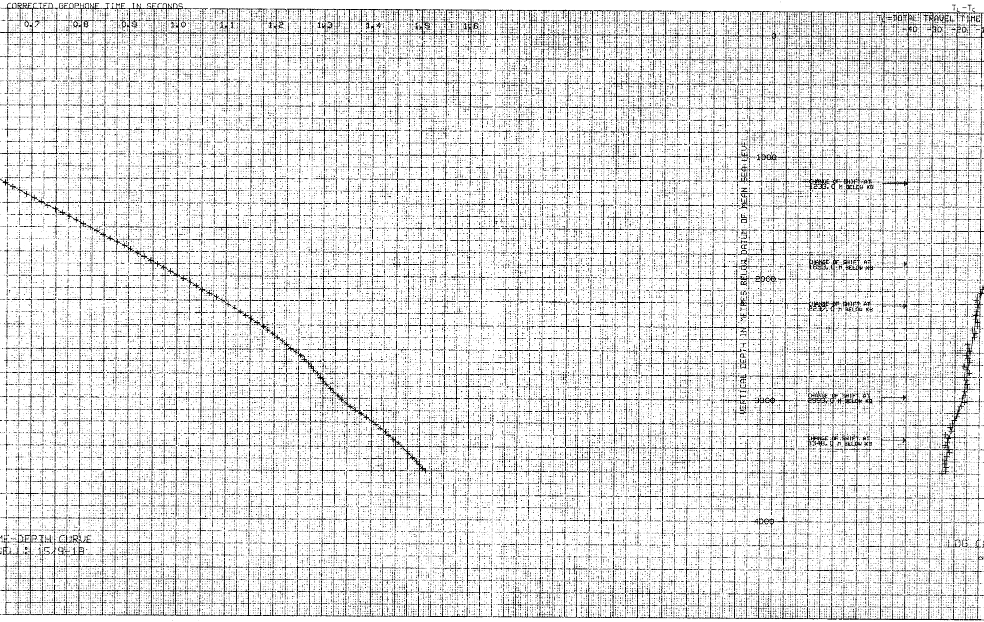
X	T	T_V	T_E	T_C	AVERAGE VELOCITY	INTERVAL DEPTH	INTERVAL TIME	INTERVAL VELOCITY
M	S	S	S	S	M/S	M	S	M/S
						80.0	0.0192	4165
60.4	1.5036	1.5054	0.0068	1.5122	2379			

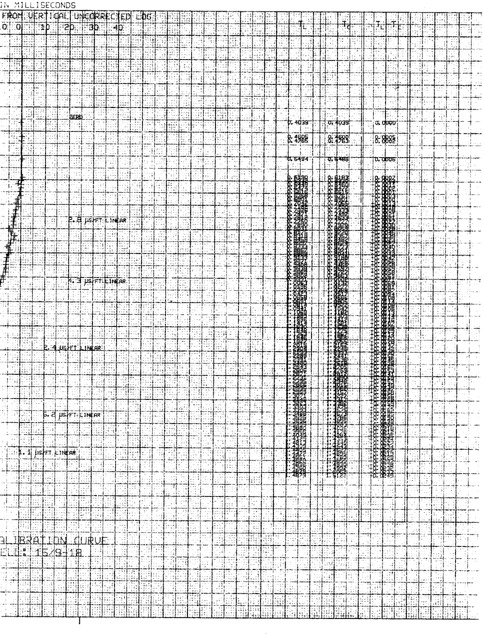
TROUGH ON THE GUN HYDROPHONE SIGNAL TO THE FIRST TROUGH ON THE WELL GEOPHONE SIGNAL.
CEDURE WHERE POSSIBLE. MANUALLY PICKED TIMES ARE MARKED *

M THE GUN TO GUN HYDROPHONE AT WATER VELOCITY IS ADDED TO T BEFORE CORRECTION TO THE VERTICAL.

L GEOPHONE CORRECTED TO THE VERTICAL.







Linear Shifts are calculated using the formula:-

$$\frac{(t_L - t_c)_2 - (t_L - t_c)_1}{Z_1 - Z_2}$$

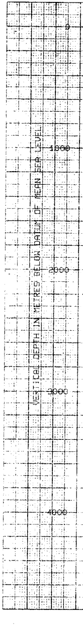
where t_L and t_c are the travel times to adjacent check levels measured from the velocity log and geophone records respectively. The result is expressed in µs/ft. The linear shifts are applied only when the correction is negative as the log error in this case is assumed to be instrumental in origin.

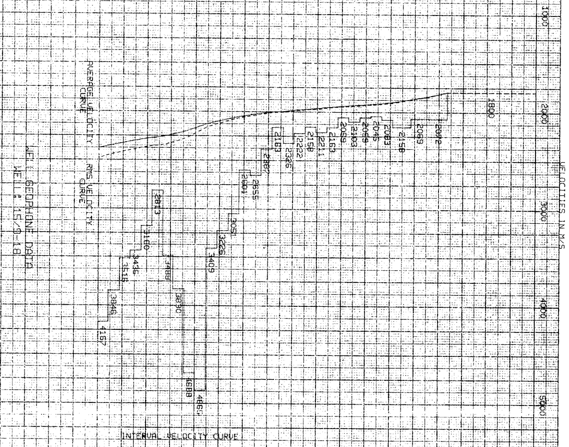
Differential Shifts are calculated using the formula:-

$$\frac{t_{c_2} - t_{c_1}}{t_{L_2} - t_{L_1}} \times 100\%$$

They are applied whenever the calibration data indicates a shift towards higher velocities. Because the lower velocities are assumed to have contributed more transit time error than higher velocities due to caving, and other borehole effects, lower velocity sections of log receive larger corrections than higher velocity sections.

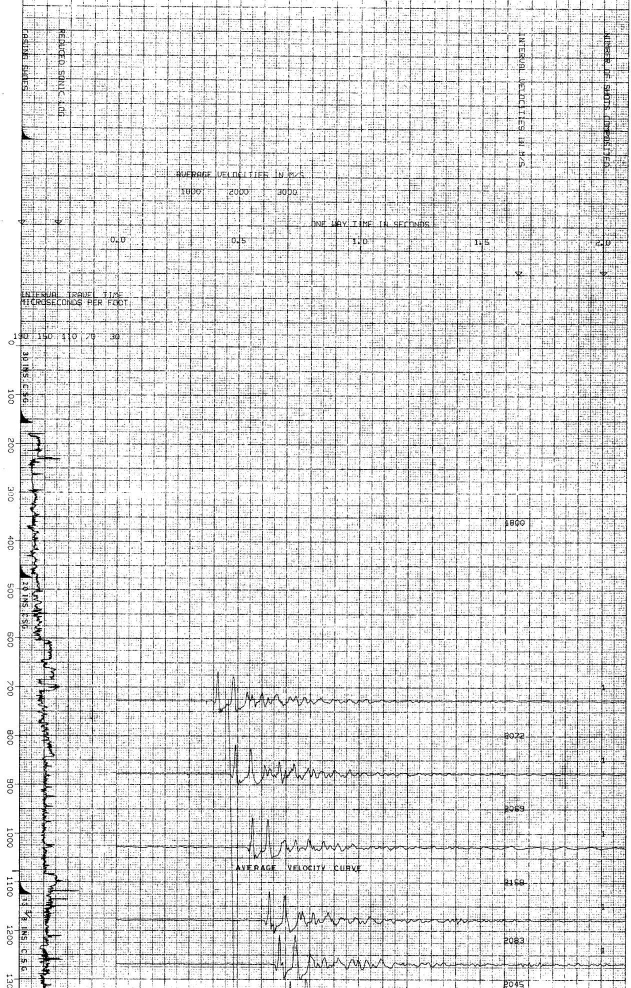
M214

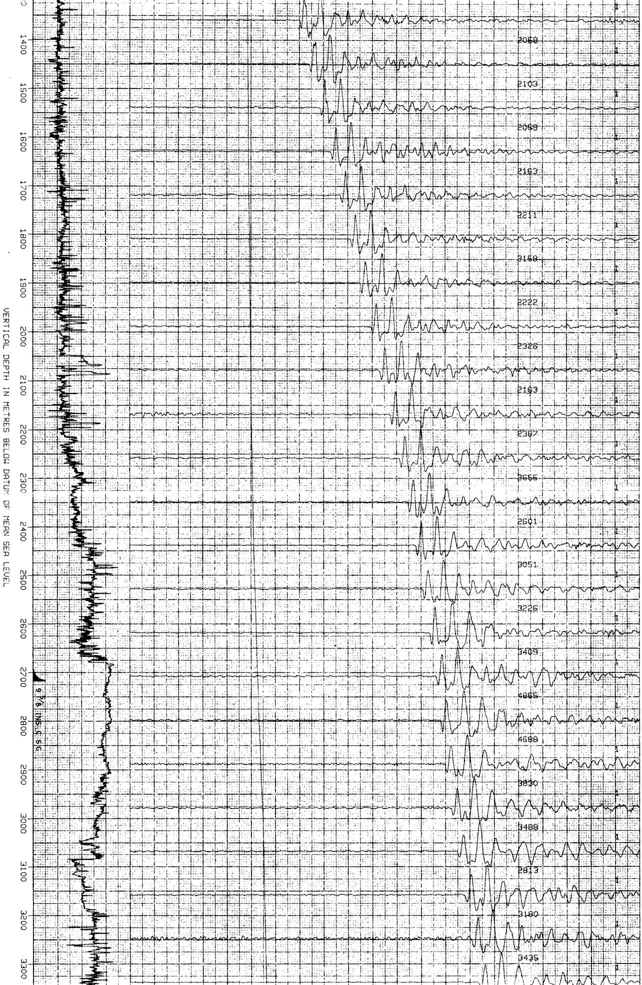


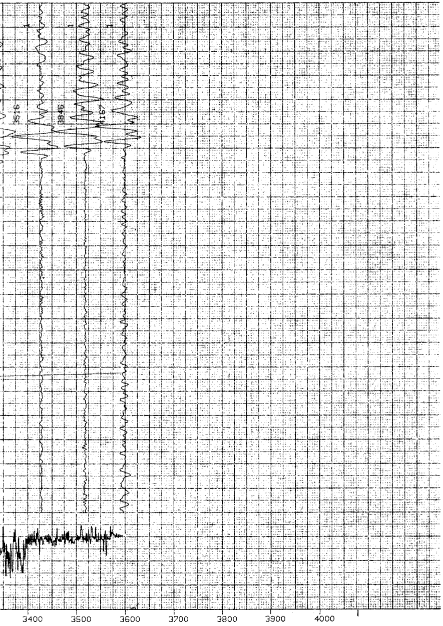


SECTIONAL DISPLAY OF WELL GEOPHONE SIGNALS

RECORDING PARAMETERS	PROCESSING PARAMETERS
GUN SIZE : 80 IN³	SCALE : HORIZONTAL 10 CM = 1 S VERTICAL 1 CM = 50 M
GUN PRESSURE : 2000 LB/IN²	DATUM : MEAN SEA LEVEL
GUN DEPTH : 10.0 M	SAMPLING INTERVAL : 2MS
	FILTER : NONE
	OTHER TECHNIQUES : NONE
	JOB NUMBER 530329 DATE 16 3 84







WELL: 15/9-18

C O M M E N T

WELL GEOPHONE SURVEY:

The first arrival on the well geophone signal is generally well defined. The check levels were shot approximately every 30 m from 3620-1200 m below KB and then approximately every 150 m from 1050-750 m below KB. The monitor records have been labelled 1-91. There are no records for the check levels between 1830 and 2010 m below KB but data were recorded on tape.

The picked times have been modified using an automated trace alignment procedure, which gives improved timing accuracy and better alignment for VSP processing. Where the waveform of the well geophone signal shows some variation, spurious adjustments that are not related to formation velocities can be introduced. The check levels at 1255, 3060 and 3090 m below KB were not considered suitable for use in the trace alignment procedure and manually picked times have been used for these levels.

The check level at 867 m below KB was shot twice during the survey, once at the beginning of the survey as the tool descended and again at the end as the tool ascended (records 1 and 90). The times were compatable but in order to maintain a consistent waveform for inclusion in the trace alignment procedure only shots taken in sequence as the tool ascended have been used and, therefore, only record no.90 has been included in the final computations.

All check levels have been included in the final report, but for interval velocity calculations have been combined, where possible, to give 90 m intervals. The same check levels have been used for the production of the sectional display of well geophone signals.

ACOUSTIC LOGS.

The acoustic logs are generally well recorded. Several sections are affected by noise, cycle skipping or washout. These sections have been edited by STATOIL. The integrator has been extrapolated 4 m below the bottom of the log in order to include the check level at 3620 m below KB in the calibration.

CALIBRATION:

The calibration is generally well controlled by the check level data with the majority of points lying within ± 1 ms of the chosen curve.

There is no check level data above 750 m below KB. The zero shift applied above 1233 m below KB has been continued up to the top of the log at 201.5 m below KB. This results in a velocity between seabed and the top of the recorded log of 1624 m/s (187 us/ft) which seems reasonable.

Approved by:

Ruth Coleman
....
P. Kennett
Manager, Well Survey Division

Processed by:

G. Tootill
....
A. G. Tootill

15th March 1984

MS/E