

Seismic Velocity Survey

And

Log Calibration



VS-18089

Exxon Company U.S.A.

OCS-P-0182 No. 2

Santa Barbara Channel

Offshore California

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MINERALS MGT. SERVICE
VENTURA DISTRICT

**PROPRIETARY GEOPHYSICAL
INFORMATION**



Conducted For

Exxon Company U.S.A.

Birdwell Division



Seismograph Service Corporation

A SUBSIDIARY OF RAYTHEON COMPANY

P.O. BOX 1590

TULSA, OKLAHOMA 74102

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INTRODUCTION

A Seismic Velocity Survey was conducted for the Exxon Company U.S.A. in their OCS-P-0182 No. 2 well located in the Santa Barbara Channel, Offshore California. The survey was conducted by the Birdwell Division of Seismograph Service Corporation on April 20, 1980.

A borehole compensated Sonic Log, digitized and integrated from 2644 ft. K.B. to 12,456 ft. K.B., was calibrated to the geophone survey data. The borehole was deviated. Depth corrections to vertical were based on a subsurface directional survey furnished by Exxon Company U.S.A. Unless stated otherwise all depths in this report refer to true vertical depths.

OPERATION STATISTICS

Surface conditions:	Favorable
K.B. elevation:	+ 38 ft.
Water depth:	1111 ft.
Casing depth:	5616 ft. K.B.
Seismic datum elevation:	Sea Level
Well T.D.:	12,481 ft. K.B.
Air gun location:	65 ft. Southeast of well
Depth of air gun and time break hydrophone:	35 ft.
Survey based on:	K.B.
Number of levels tested:	53

OPERATION STATISTICS (Cont.)

Upper geophone level tested:	1250 ft. K.B. (meas.)
Deepest geophone level tested:	12,137 ft. K.B. (meas.)
Quality of geophone breaks:	Poor to Fair
Elevation velocity (V_e):	5000 ft./sec.

INSTRUMENTATION

Energy source:	Bolt par model 1900C air gun
Air gun chamber used:	200 cu. in.
Gas pressure on gun:	1200 psi
Pressure source:	Bottled gas
Time break hydrophone:	Attached to gun
Downhole detector:	Six 15 Hz. geophones connected in parallel
Downhole amplification:	40 db
Borehole coupling:	Surface controlled arm
Surface amplification:	Floating point amplifier
Recording:	S.S.C. model IDPC-1100 floating point digital well survey recording system
Tape format :	9 track, IBM compatible
Recording mode:	800 bpi NRZI
Sample rate:	1 millisecond
Trace polarity:	
Digital tape playouts:	Time breaks: down Geophone breaks: down

FIELD PROCEDURE

Standard practice, using the wall-coupled geophone, is to lower the instrument to the level to be tested, open the coupling device, slacken the cable, shoot, pick up the slack, retract the coupling device and then move to the next level where the cycle is repeated. Slackening the cable while the phone is coupled to the wall minimizes the effect of any cable-borne energy.

RESULTS AND INTERPRETATION

Seismic

The digital tape data have been vertically stacked for each level producing a stacked trace display. The data used for the calculations consist of the times of the stacked traces for each level. These time data are tabulated with the velocities and calculation steps on the velocity calculation sheets in the appendix. Sea bed, at a reported depth of 1111 ft. below sea level, is considered a velocity interface, and the computed interval velocities shown in the tabulation include this level. A computer plot of the time-depth, average and interval velocities, with a reduced scale plot of the calibrated velocity log, is included in the appendix. The traces were edited and arranged according to depth.

Relative Amplitude Plot

A relative amplitude comparison was made between the downhole geophone and the time break hydrophone, which is attached to the air gun. The comparison is shown as a plot of the RMS ration of the received

Relative Amplitude Plot (Cont.)

signal to the source signal. The RMS values were computed over a 400 ms window of the source signal and of the downhole geophone signal. The ratio of the RMS values is computed, converted to db, and plotted at the indicated depths. This plot, which shows the relative amplitude decay, is included in the appendix.

Velocity Log

The time depth values obtained from the velocity survey are used to calibrate the interval transit time log. The measured timed intervals from the survey are compared with the corresponding integrated time intervals from the interval transit time log. A plot is made indicating the differences between the geophone data and the log, and from this plot adjustments are determined and applied to the log. This plot is labeled Deviation Plot, and is included in the appendix. The adjustments determined from the deviation plot are applied by moving the interval transit time curve laterally in such a way that when re-integrated the log times will agree closely with the well geophone times. The lateral adjustments consist of a linear or differential shift.

Linear shifts are calculated using the equation:

$$\text{Shift} = \frac{t_{A2} - t_{A1}}{D_1 - D_2} \times 10^6$$

where D is the depth of the adjustment point, and t_A is the amount of time adjustment indicated by the adjustment point.

Velocity Log (Cont.)

The result is expressed in $\mu\text{s}/\text{ft}$. The linear shifts are applied only when the equation is positive as the log error in this case is assumed to be instrumental in origin. When the equation is negative a differential shift is used.

Differential shifts are calculated using the equation:

$$\% \text{ Shift} = \frac{(t_L - t_A)_2 - (t_L - t_A)_1}{t_{L2} - t_{L1}} \times 100$$

where t_L is the travel time from the interval transit time log at the adjustment point, and t_A is the amount of time adjustment indicated by the adjustment point. Differential shifts are applied whenever the calibration data indicates a shift towards higher velocities. The lower velocities, due to bore-hole effects, are assumed to have contributed more transit time error than higher velocities. Therefore, lower velocity sections of the log receive larger corrections than higher velocity sections. Differential shifts are expressed as a percentage of the interval transit time log values. In both equations above, subscript 1 corresponds with the shallow adjustment point, and subscript 2 corresponds with the deep adjustment point. (See Deviation Plot)

The adjustments to the log interval time data are listed on the calibrated log heading, and have been absorbed into the natural velocity contrasts as recorded on the interval transit time log. The total travel times for the geophone levels as shown by the calibrated log, and indicated time differences between the geophone and calibrated log data, are

Velocity Log (Cont.)

listed on the calibrated velocity log data sheets in the appendix. The time differences are minimal.

Three copies of the calibrated interval transit time log are included in the report pocket: One at a linear depth scale of 1" = 100', one at a linear time scale of 2 ½" per second, two way time, and one at a linear time scale of 5" per second, two way time. A computer print-out of the calibrated log data, listing one and two way travel times, depth, interval and average velocities, is included in the appendix.

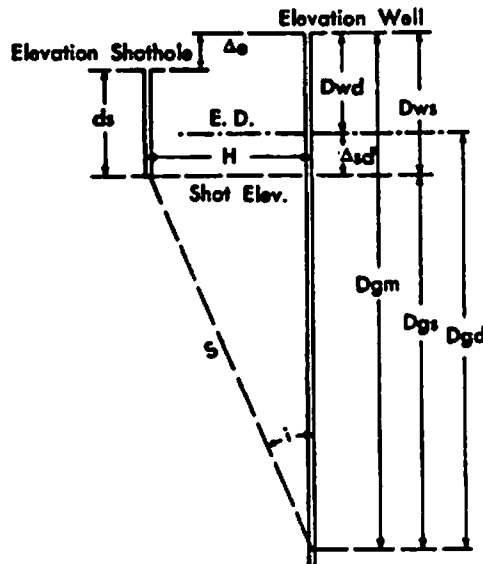
The results from the combined survey and velocity log are good, and the data are considered reliable.

Respectfully submitted,

Birdwell Division of
Seismograph Service Corporation

Date July 1, 1980 By Kevin Higgins
Kevin Higgins

CROSS-SECTION AND DEFINITION OF TERMS



- D_{gm} = Geophone depth below well elevation
- D_{wd} = Difference between well elevation and elevation datum = $E_w - ED$
- D_{gd} = Geophone depth below elevation datum = $D_{gm} - D_{wd}$
- t_s = Uphole time in shothole
- t_r = Refraction time from reference geophone
- d_s = Depth of shot
- H = Horizontal distance from well to shothole
- Δs_d = Difference between shot elevation and elevation datum = $E_s - d_s - ED$
- D_{gs} = Geophone depth below shot elevation = $D_{gd} + \Delta s_d$
- $\cos i$ = $D_{gs} / \sqrt{H^2 + D_{gs}^2}$
- T = Observed travel time from shot to well geophone
- G_r = Quality grade of well geophone "break"
- T_{gs} = Travel time for D_{gs} distance = $T \cos i$
- $\Delta s_d / v_e$ = Time correction from shot to elevation datum
- T_{gd} = Travel time for D_{gd} distance = $T_{gs} - \Delta s_d / v_e$
- v_a = Average velocity to depth D_{gd} = D_{gd} / T_{gd}
- ΔD_{gd} = Interval distance = $D_{gd_n} - D_{gd_m}$
- ΔT_{gd} = Interval time for ΔD_{gd} distance = $T_{gd_n} - T_{gd_m}$
- v_i = Interval velocity = $\Delta D_{gd} / \Delta T_{gd}$
- S = Direct diagonal distance from shot to geophone = $D_{gs} / \cos i$
- ED = Elevation or reference datum
- v_e = Elevation correction velocity
- Δe = Difference between well elevation and shothole elevation = $E_w - E_s$

Birdwell Division



Seismograph Service Corporation

P.O. BOX 1500

TULSA, OKLAHOMA 74102

PROPRIETARY GEOPHYSICAL
INFORMATION

AIR GUN SEISMIC VELOCITY SURVEY

Exxon Company U.S.A.


OCS-P-0182 No. 2

Santa Barbara Channel, Offshore California

ELEV. K.B. - + 38 Ft.		Dwd + 38 Ft.		TOTAL DEPTH 12,481 ft. K.B.			CSG DEPTH 5616 ft. K.B.			ELEV. DATUM Sea Level			ELEV. VEL., Vv. 5000 ft./sec.			DATE April 20, 1980				
LEVEL	FILE OR RECORD NUMBERS	AIR GUN DEPTH	GUN PRESS. PSI	MEASURED Dgm	VERTICAL Dgm	Dgd	Δ_{sd}	Dgs	H Dist.	Cor 1	Avg. T	Gr.	Tgs	$\frac{\Delta_{sd}}{Vv}$	Tgd	Vv	ΔDgd	ΔTgd	Vt	
	Sea Level			38	38	0												1111	.2222	5000
	Sea Bed			1149	1149	1111									.2222	5000				
A	304-300	35	1200	1250	1250	1212	-35	1177	65	.9985	?			+ .0070			851	.1586	5366	
B	292-296	35	1200	1500	1500	1462	-35	1427	65	.9990	?			+ .0070						
C	295-292	35	1200	1750	1750	1712	-35	1677	65	.9992	?			+ .0070						
D	291-288	35	1200	2000	2000	1962	-35	1927	66	.9994	.374	P	.3738	+ .0070	.3808	5152	250	.0480	5208	
E	287-284	35	1200	2250	2250	2212	-35	2177	67	.9995	.422	P	.4218	+ .0070	.4288	5159	250	.0390	6410	
F	283-280	35	1200	2500	2500	2462	-35	2427	67	.9996	.461	P	.4608	+ .0070	.4678	5263	249	.0450	5533	
G	279-276	35	1200	2750	2749	2711	-35	2676	70	.9997	.506	F	.5058	+ .0070	.5128	5287	250	.0410	6098	
H	1-4 275-272	35	1200	3000	2999	2961	-35	2926	70	.9997	.547	P	.5468	+ .0070	.5538	5347	250	.0431	5800	
I	271-268	35	1200	3250	3249	3211	-35	3176	64	.9998	.590	P	.5899	+ .0070	.5969	5379	250	.0390	6410	
J	267-264	35	1200	3500	3499	3461	-35	3426	61	.9998	.629	F	.6289	+ .0070	.6359	5443	250	.0400	6250	
K	263-260	35	1200	3750	3749	3711	-35	3676	61	.9999	.669	P	.6689	+ .0070	.6759	5490	500	.0790	6329	
L	259-256	35	1200	4000*	3999	3961	-35	3926	57	.9999	.705	F	.7049	+ .0070	.7119	5564				
H	255-252	35	1200	4250	4249	4211	-35	4176	64	.9999	.748	F	.7479	+ .0070	.7549	5578	249	.0370	6730	
H	251-246	35	1200	4500	4498	4460	-35	4425	72	.9999	.785	P	.7849	+ .0070	.7919	5632	250	.0350	7143	
O	245-242	35	1200	4750	4748	4710	-35	4675	79	.9999	.820	P	.8199	+ .0070	.8269	5696	250	.0370	6757	
P	241-238	35	1200	5000	4998	4960	-35	4925	84	.9999	.857	P	.8569	+ .0070	.8639	5741				
Q	237-234	35	1200	5250*	5248	5210	-35	5175	85	.9999	.888	P	.8879	+ .0070	.8949	5822	499	.0710	7028	
R	233-230	35	1200	5500	5497	5459	-35	5424	77	.9999	.928	F	.9279	+ .0070	.9349	5839	250	.0320	7813	
S	229-226	35	1200	5750	5747	5709	-35	5674	70	.9999	.960	P	.9599	+ .0070	.9669	5904	249	.0350	7114	
T	5-9 225-222	35	1200	6000	5996	5958	-35	5923	72	.9999	.995	F	.9949	+ .0070	1.0019	5947	80	.0130	6154	
U	221-218	35	1200	6080	6076	6038	-35	6003	72	.9999	1.008	P	1.0079	+ .0070	1.0149	5949	169	.0200	8450	
V	217-214	35	1200	6250	6245	6207	-35	6172	73	.9999	1.028	P	1.0279	+ .0070	1.0349	5998	165	.0220	7500	
W	213-209	35	1200	6415	6410	6372	-35	6337	77	.9999	1.050	P	1.0499	+ .0070	1.0569	6029	85	.0100	8500	
X	208-204	35	1200	6500	6495	6457	-35	6422	80	.9999	1.060	P	1.0599	+ .0070	1.0669	6052				

*Depth Questionable

Birdwell Division


 Seismograph Service Corporation
 A DIVISION OF BIRDWELL COMPANY
 P.O. BOX 1000 TULSA, OKLAHOMA 74103

AIR GUN SEISMIC VELOCITY SURVEY

 Exxon Company U.S.A.
 OCS-P-0182 No. 2
 Santa Barbara Channel, Offshore California

ELEV. K.B. = ± 38 ft.		Dwd ± 38 ft.		TOTAL DEPTH 12,581 ft. K.B.		CSG DEPTH 5616 ft. K.B.		ELEV. DATUM Sea Level		ELEV. VEL., V _o 5000 ft. sec.		DATE April 20, 1980							
LEVEL	FILE OR RECORD NUMBERS	AIR GUN DEPTH	GUN PRESS. PSI	MEASURED Dgm	VERTICAL Dgm	Dgd	Δ d	Dge	H Dist.	Cor 1	App. T	Gr.	T _{ge}	Δ d / V _o	T _{gd}	V _o	Δ Dgd	Δ T _{gd}	V _i
Y	203-200	35	1200	6750	6742	6704	-35	6669	95	.9999	1.089	F	1.0889	+0.0070	1.0959	6117	267	.0290	8517
Z	199-196	35	1200	7020	7009	6971	-35	6936	123	.9998	1.120	F	1.1198	+0.0070	1.1268	6187	267	.0302	8641
AA	195-192	35	1200	7250	7235	7197	-35	7162	154	.9998	1.140	F	1.1398	+0.0070	1.1468	6276	226	.0200	11,300
AB	191-188	35	1200	7330	7313	7275	-35	7240	166	.9997	1.147	F	1.1467	+0.0070	1.1537	6306	78	.0069	11,304
AC	187-184	35	1200	7500	7480	7442	-35	7407	193	.9997	1.162	F	1.1617	+0.0070	1.1687	6368	167	.0150	11,123
AD	183-180	35	1200	7750	7726	7688	-35	7653	236	.9995	1.186	F	1.1854	+0.0070	1.1924	6448	246	.0237	10,380
AE	179-176	35	1200	8000	7971	7933	-35	7898	283	.9994	1.210	P	1.2093	+0.0070	1.2163	6522	245	.0232	10,251
AF	175-162	35	1200	8250	8217	8179	-35	8144	325	.9992	1.237	F	1.2360	+0.0070	1.2430	6580	246	.0267	9213
AG	161-158	35	1200	8500	8465	8427	-35	8392	354	.9991	1.261	F	1.2599	+0.0070	1.2669	6652	248	.0232	10,377
AH	157-154	35	1200	8660	8624	8586	-35	8551	369	.9991	1.275	F	1.2739	+0.0070	1.2809	6703	159	.0140	11,357
AI	153-142 10-15	35	1200	8750	8714	8676	-35	8641	377	.9990	1.286	P	1.2847	+0.0070	1.2917	6717	90	.0108	8333
AJ	141-137	35	1200	9000	8963	8925	-35	8890	397	.9990	1.309	F	1.3077	+0.0070	1.3147	6789	249	.0230	10,826
AK	136-132	35	1200	9170	9132	9094	-35	9059	411	.9990	1.328	P	1.3267	+0.0070	1.3337	6819	162	.0190	8895
AL	131-128	35	1200	9250	9212	9174	-35	9139	417	.9990	1.336	F	1.3347	+0.0070	1.3417	6838	80	.0080	10,000
AM	127-121	35	1200	9500*	9462	9424	-35	9389	435	.9989	1.353	F	1.3515	+0.0070	1.3585	6937	499	.0428	11,659
AN	120-113	35	1200	9750	9711	9673	-35	9638	451	.9989	1.379	P	1.3775	+0.0070	1.3845	6987	250	.0210	11,905
AO	112-103	35	1200	10,000	9961	9923	-35	9888	465	.9989	1.400	P	1.3985	+0.0070	1.4055	7060	249	.0189	13,175
AP	102-98	35	1200	10,250	10,210	10,172	-35	10,137	484	.9989	1.419	P	1.4174	+0.0070	1.4244	7141	249	.0232	10,418
AQ	97-92	35	1200	10,500	10,459	10,421	-35	10,386	507	.9988	1.443	P	1.4413	+0.0070	1.4483	7195	249	.0199	12,513
AR	91-82	35	1200	10,750	10,708	10,670	-35	10,635	527	.9988	1.463	F	1.4612	+0.0070	1.4682	7267	139	.0109	12,752
AS	81-77	35	1200	10,890	10,847	10,809	-35	10,774	542	.9987	1.474	F	1.4721	+0.0070	1.4791	7308	109	.0090	12,111
AT	76-70	35	1200	11,000	10,956	10,918	-35	10,883	554	.9987	1.483	F	1.4811	+0.0070	1.4881	7337	249	.0188	13,245
AU	62-66	35	1200	11,250	11,205	11,167	-35	11,132	580	.9986	1.502	F	1.4999	+0.0070	1.5069	7411	396	.0278	14,245
AV	65-52	35	1200	11,500*	11,452	11,414	-35	11,379	607	.9986	1.514	F	1.5119	+0.0070	1.5189	7515	99	.0070	14,143
AW	58-67	35	1200	11,650	11,601	11,563	-35	11,528	623	.9985	1.530	F	1.5277	+0.0070	1.5347	7534	248	.0228	10,877
AX	46-39	35	1200	11,750	11,700	11,662	-35	11,627	636	.9985	1.537	F	1.5347	+0.0070	1.5417	7564			

*Depth Questionable

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 P.O. BOX 1190 • TULSA, OKLAHOMA 74102

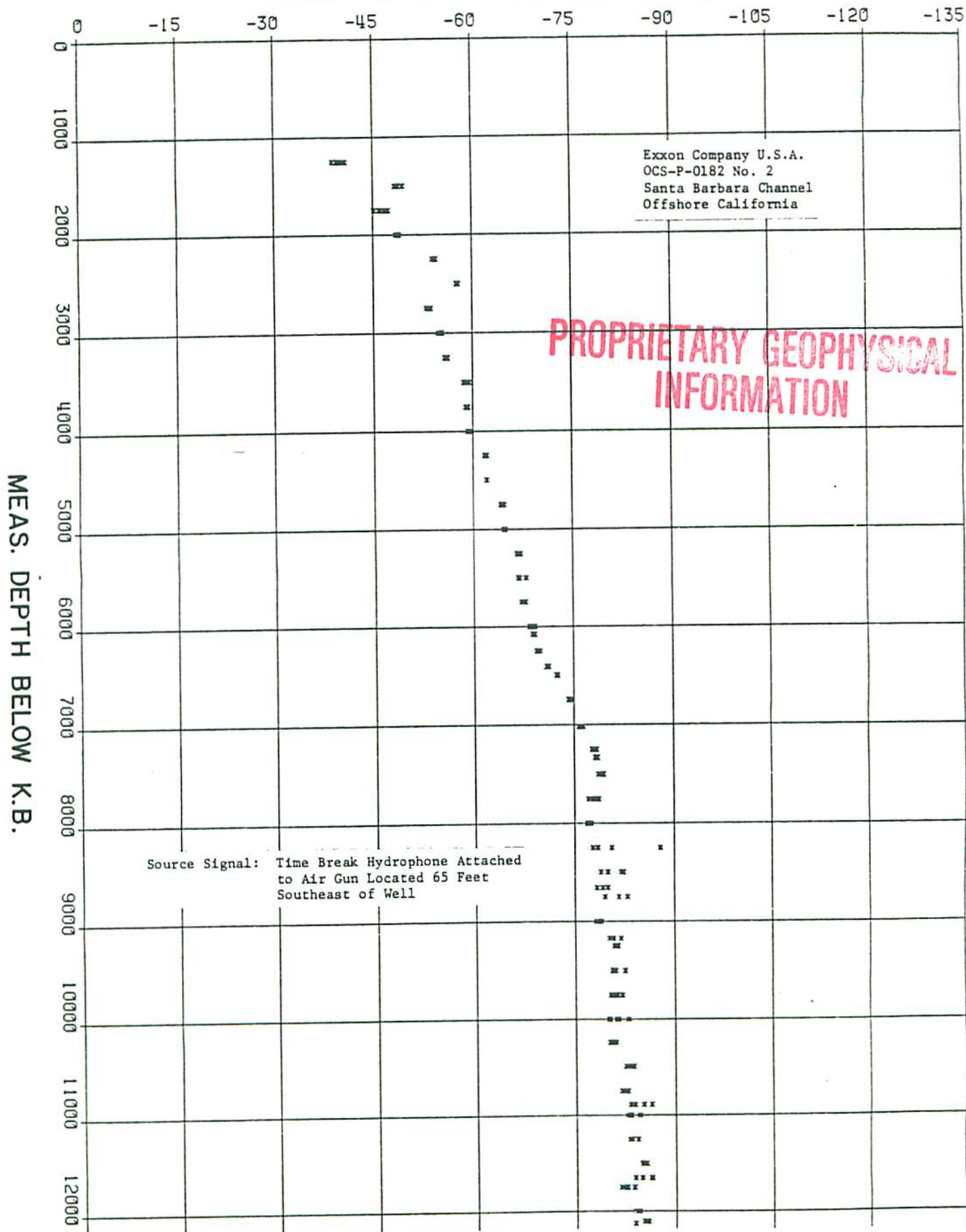
Exxon Company U.S.A.
 OCS-P-0182 No. 2
 Santa Barbara Channel, Offshore California

AIR GUN SEISMIC VELOCITY SURVEY

ELEV. LEVEL	K.B. = + 38 ft.	FILE OR RECORD NUMBERS	D _{ad} + 38 ft.	AIR GUN DEPTH	GUN PRESS. PSI	MEASURED D _{gm}	TOTAL DEPTH 12,481 ft. K.B.	VERTICAL D _{gm}	D _{vd}	Δ d	D _{gs}	H Dist.	Cos I	A _g T	Gr.	T _{gs}	Δ d / T _{gs}	T _{gd}	V _s	Δ D _{gd}	Δ T _{gd}	VI
AY	38-30		35	1200	1200	12,000	11,948	11,910	-35	11,875	668	.9984	1.560	P	1.5575	+0.0070	1.5645	7613	135	.0100	13,500	
AZ	29-20		35	1200	1200	12,117*	12,064	12,026	-35	11,991	680	.9984	1.560	P	1.5575	+0.0070	1.5645	7687				
BA	19-16		35	1200	1200	12,137	12,083	12,045	-35	12,010	683	.9984	1.570	P	1.5675	+0.0070	1.5745	7650				
						*Depth questionable																

PROPRIETARY GEOPHYSICAL
INFORMATION

RELATIVE AMPLITUDE IN DB





Exxon Company U.S.A.
 OCS-P-0182 No. 2
 Santa Barbara Channel, Offshore California

ELEV.		ELEV. DAT.	T.D.	DATE	
K.B. = + 38 ft.		Sea Level	12,481 ft. K.B.	April 20, 1980	
T.V. DEPTH BELOW		ITEM	LOG Tgd	GEO. Tgd	DIFF.
K.B.	DATUM				
1149	1111	Sea Bed	.2222	.2222	.0000
1250	1212	Geophone Level	.2410	-----	-----
1500	1462	Geophone Level	.2876	-----	-----
1750	1712	Geophone Level	.3342	-----	-----
2000	1962	Geophone Level	.3808	.3808	.0000
2250	2212	Geophone Level	.4288	.4288	.0000
2500	2462	Geophone Level	.4678	.4678	+ .0000
2749	2711	Geophone Level	.5114	.5128	- .0014
2999	2961	Geophone Level	.5541	.5538	+ .0003
3249	3211	Geophone Level	.5952	.5969	- .0017
3499	3461	Geophone Level	.6356	.6359	- .0003
3749	3711	Geophone Level	.6753	.6759	- .0006
3999	3961	Geophone Level	.7147	-----	-----
4249	4211	Geophone Level	.7531	.7549	- .0018
4498	4460	Geophone Level	.7906	.7919	- .0013
4748	4710	Geophone Level	.8258	.8269	- .0011
4998	4960	Geophone Level	.8639	.8639	.0000
5248	5210	Geophone Level	.8998	-----	-----
5497	5459	Geophone Level	.9342	.9349	- .0007
5747	5709	Geophone Level	.9686	.9669	+ .0017
5996	5958	Geophone Level	1.0028	1.0019	+ .0009
6076	6038	Geophone Level	1.0140	1.0149	- .0009
6245	6207	Geophone Level	1.0372	1.0349	+ .0023
6410	6372	Geophone Level	1.0577	1.0569	+ .0008
6495	6457	Geophone Level	1.0677	1.0669	+ .0008

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ELEV.		ELEV. DAT.	T.D.	DATE	
K.B. = + 38 ft.		Sea Level	12,481 ft. K.B.	April 20, 1980	
T.V. DEPTH BELOW		ITEM	LOG Tgd	GEO. Tgd	DIFF.
K.B.	DATUM				
6742	6704	Geophone Level	1.0964	1.0959	+ .0005
7009	6971	Geophone Level	1.1248	1.1268	- .0020
7235	7197	Geophone Level	1.1453	1.1468	- .0015
7313	7275	Geophone Level	1.1526	1.1537	- .0011
7480	7442	Geophone Level	1.1685	1.1687	- .0002
7726	7688	Geophone Level	1.1917	1.1924	- .0007
7971	7933	Geophone Level	1.2168	1.2163	+ .0005
8217	8179	Geophone Level	1.2424	1.2430	- .0006
8465	8427	Geophone Level	1.2658	1.2669	- .0011
8624	8586	Geophone Level	1.2814	1.2809	+ .0005
8714	8676	Geophone Level	1.2905	1.2917	- .0012
8963	8925	Geophone Level	1.3159	1.3147	+ .0012
9132	9094	Geophone Level	1.3335	1.3337	- .0002
9212	9174	Geophone Level	1.3405	1.3417	- .0012
9462	9424	Geophone Level	1.3625	-----	-----
9711	9673	Geophone Level	1.3837	1.3845	- .0008
9961	9923	Geophone Level	1.4055	1.4055	.0000
10,210	10,172	Geophone Level	1.4252	1.4244	+ .0008
10,459	10,421	Geophone Level	1.4470	1.4483	- .0013
10,708	10,670	Geophone Level	1.4678	1.4682	- .0004
10,847	10,809	Geophone Level	1.4789	1.4791	- .0002
10,956	10,918	Geophone Level	1.4872	1.4881	- .0009
11,205	11,167	Geophone Level	1.5059	1.5069	- .0010
11,452	11,414	Geophone Level	1.5244	-----	-----
11,601	11,563	Geophone Level	1.5355	1.5347	+ .0008



Exxon Company U.S.A.
 OCS-P-0182 No. 2
 Santa Barbara Channel, Offshore California

ELEV.		ELEV. DAT.	T.D.	DATE	
K.B. = + 38 ft.		Sea Level	12,481 ft. K.B.	April 20, 1980	
T.V DEPTH BELOW		ITEM	LOG Tgd	GEO. Tgd	DIFF.
K.B.	DATUM				
11,700	11,662	Geophone Level	1.5434	1.5417	+0.0017
11,948	11,910	Geophone Level	1.5627	1.5645	-0.0018
12,064	12,026	Geophone Level	1.5709	-----	-----
12,083	12,045	Geophone Level	1.5724	1.5745	-0.0021

PROPRIETARY GEOPHYSICAL
 INFORMATION