

GLO2475

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SEISMIC DATA EVALUATION OF GEOTHERMAL POTENTIAL ON SODA LAKE

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SOURCES

A compilation of sources to date indicates that there are:

1. Geological descriptions and maps of the area performed for the USGS (1964).
2. A migrated contour map of a near surface phantom horizon taken from a shallow reflection seismic survey. This survey used a weight dropping technique for the source, and a single channel field summer for the receiver. It covered approximately a 15 square mile area with a rectangular grid of 7 lines (1975).
3. Four wells with logs and a geological evaluation of core samples (1975). Carson sink #1, 1-29, 44-5, and 36-78.
4. A grid of 3, 12-fold lines using dynamite at a hole depth of 150' (1978).

EVALUATION

An evaluation of three 12-fold lines confirms the existence of the angular unconformity postulated on the earlier seismic work, and better defines the faulting pattern above the angular unconformity.

However, the essential results which indicates the best surface position for drilling is a deep (4000') band of energy below which there appears to be no reflections. This band of energy indicates the possibility of a basement to the sedimentary section which the core samples from the wells seem to confirm.

This basement appears at one time to have been a dome or ridge which was faulted with some 2000' throw, followed by a period of deposition. A major event followed by deposition created the unconformity. The scenario then indicates a period of deposition terminating with pressures near the apex of the anticline which produced a distinctive faulting pattern near the surface (Line 3). This is clearly indicated by a contour map of the unconformity.

To clarify the prime result, a phantom horizon of the basement band was mapped and contoured along with a map and contour of a phantom of a near surface band. This map can perhaps be used with the aid of areal photos to verify or substantiate the strikes of the near surface faults.

Processing and Quality of Seismic Data

The recent seismic data was recorded with an 18 CPS low cut filter and a 124 CPS high cut. If one uses the maximum resolution criterion of 1/3 of a wavelength, then the smallest fault resolution possible would be 16' or approximately 5 mils on the shallow section.

$$v = f\lambda \quad \lambda = 50'$$

$$6000 = 125\lambda \quad 1/3\lambda = 16'$$

The fault displacements on line three appear to be:

SHOT POINT	APPROXIMATE 2 WAY RECORD TIME	ONE WAY RECORD TIME	RECORD TIME CORRECTED TO SURFACE	DISPLACEMENT TIME		DISPLACEMENT
				2 Way	1 Way	
53	.2	.1	.133	.005	.0025	910-888 = 22'
50	.2	.1	.133	.010	.005	932-888 = 44'
41	.2	.1	.133	.015	.0075	954-888 = 66'
35	.25	.125	.158	.035	.0175	1215-1117= 168'
26	.25	.125	.158	.020	.010	1215-1117= 98'
17	.30	.150	.183	.010	.005	1447-1393= 54'

LINE 2

SHOT POINT	APPROXIMATE 2 WAY RECORD TIME	ONE WAY RECORD TIME	RECORD TIME CORRECTED TO SURFACE	DISPLACEMENT TIME		DISPLACEMENT
				2 Way	1 Way	
69	.250	.125	.158	.040	.020	1320-1117=203'
60	.250	.125	.158	.005	.0025	1141-1117=24'
51	.220	.110	.143	.020	.010	1069-977=92'
46	.220	.110	.143	.020	.010	1-69-977=92'
21-27	.200	.100	.133	.020	.010	976-888=88'
15	.200	.100	.133	.005	.0025	910-888=22'
9	.20	.100	.133	.008	.004	923-888=35'

LINE 1

22	.220	.110	.143	.010	.005	1023-977=46'
12	.220	.110	.143	.005	.0025	1000-977=23'

A note about the processing sequence which has relevance to the detection of faults and position of their boundaries indicates that:

1. There appears to have been no band limited filter applied after deconvolution (Deconvolution can add spurious high frequencies to the data).
2. Automatic statics appeared to have been applied. The band of high quality data over which a correlation gate could have been placed seems limited and perhaps some small faults could have been smoothed over depending upon the intricacies of the automatic static program.
3. No diffraction-summation migration program was run on the data which may be critical to the exact location of faulting interfaces.

GENERAL COMMENTS

The 12 fold deconvolved seismic data is superior to the other sources in the detection and location of faults near the surface. But because of velocity errors or statics problems, only one horizon is mappable.

The only available velocity information to convert time to depth is an instantaneous velocity function computed from the sonic log on the Chevron Phillips Soda Lake No. 1-29 well. ($V_i = 5000 + 4.16Z$ for $Z < 1200$; $V_i = 10,000$ for > 1200 ft.)

This function was used to generate a table of one-way time versus depth in feet for depth conversion. The two way times for the horizon to be mapped were picked from the seismic sections and listed for variously spaced (Tables 1, 2, 6, 7, 8) shot-points. The times were halved and looked up in the computer printout for a corresponding depth.

SODA LAKE
Velocity Information
Chevron Well 1-29
Vi=5000+4.16Z For Z < 1200'
Vi=10,000 For Z ≥ 1200

Time Seconds	Depth (Ft.) Below Surface	Time Seconds	Depth (Ft.) Below Surface
0.000	-0.01	0.041	223.50
0.001	5.00	0.042	229.45
0.002	10.03	0.043	235.41
0.003	15.08	0.044	241.41
0.004	20.16	0.045	247.42
0.005	25.25	0.046	253.46
0.006	30.37	0.047	259.53
0.007	35.50	0.048	265.62
0.008	40.66	0.049	271.74
0.009	45.84	0.050	277.89
0.010	51.04	0.051	284.05
0.011	56.26	0.052	290.25
0.012	61.51	0.053	296.47
0.013	66.78	0.054	302.71
0.014	72.06	0.055	308.99
0.015	77.37	0.056	315.29
0.016	82.71	0.057	321.61
0.017	88.06	0.058	327.96
0.018	93.44	0.059	334.34
0.019	98.84	0.060	340.74
0.020	104.26	0.061	347.17
0.021	109.71	0.062	353.63
0.022	115.18	0.063	360.12
0.023	120.67	0.064	366.63
0.024	126.18	0.065	373.17
0.025	131.72	0.066	379.73
0.026	137.28	0.067	386.32
0.027	142.86	0.068	392.95
0.028	148.47	0.069	399.59
0.029	154.10	0.070	406.27
0.030	159.75	0.071	412.97
0.031	165.42	0.072	419.71
0.032	171.12	0.073	426.47
0.033	176.85	0.074	433.25
0.034	182.60	0.075	440.07
0.035	188.37	0.076	446.92
0.036	194.16	0.077	453.79
0.037	199.98	0.078	460.69
0.038	205.83	0.079	467.63
0.039	211.69	0.080	474.58
0.040	217.59	0.081	481.57

SODA LAKE
Velocity Information (cont.)

Time Seconds	Depth (Ft.) Below Surface	Time Seconds	Depth (Ft.) Below Surface
0.082	488.59	0.134	896.85
0.083	495.64	0.135	905.60
0.084	502.71	0.136	914.38
0.085	509.82	0.137	923.21
0.086	516.96	0.138	932.06
0.087	524.12	0.139	940.96
0.088	531.32	0.140	949.89
0.089	538.54	0.141	958.86
0.090	545.80	0.142	967.87
0.091	553.08	0.143	976.92
0.092	560.40	0.144	986.00
0.093	567.74	0.145	995.12
0.094	575.12	0.146	1004.28
0.095	582.53	0.147	1013.47
0.096	589.97	0.148	1022.71
0.097	597.44	0.149	1031.98
0.098	604.94	0.150	1041.30
0.099	612.47	0.151	1050.65
0.100	620.03	0.152	1060.04
0.101	627.63	0.153	1069.47
0.102	635.26	0.154	1078.94
0.103	642.92	0.155	1088.45
0.104	650.61	0.156	1097.99
0.105	658.33	0.157	1107.58
0.106	666.08	0.158	1117.21
0.107	673.87	0.159	1126.88
0.108	681.69	0.160	1136.58
0.109	689.54	0.161	1146.33
0.110	697.43	0.162	1156.12
0.111	705.35	0.163	1165.95
0.112	713.30	0.164	1175.82
0.113	721.28	0.165	1185.73
0.114	729.30	0.166	1195.69
0.115	737.35	0.167	1205.68
0.116	745.43	0.168	1215.72
0.117	753.55	0.169	1225.80
0.118	761.70		
0.119	769.89		
0.120	778.11		
0.121	786.36		
0.122	794.65		
0.123	802.97		
0.124	811.33		
0.125	819.72		
0.126	828.15		
0.127	836.62		
0.128	845.11		
0.129	853.65		
0.130	862.21		
0.131	870.82		
0.132	879.46		
0.133	888.14		

The depths below 3800 ft (reference plane) and above 2600 ft obey the relationship.

$$V_i = 5000 + 4.16Z$$

$$\frac{dZ}{dt} = 5000 + 4.16Z$$

$$\frac{dZ}{5000 + 4.16Z} = dt$$

$$\int \frac{dZ}{5000 + 4.16Z} = t + C$$

$$\frac{1}{4.16} \ln(5000 + 4.16Z) = t + C$$

$$\ln(5000 + 4.16Z) = 4.16(t + C)$$

$$e^{4.16(t + C)} = 5000 + 4.16Z$$

$$t=0 \quad Z=0$$

$$e^{4.16C} = 5000$$

$$C = 2.0474$$

$$\frac{(e^{4.16(t + C)} - 5000)}{4.16} = Z$$

One way time, depth below 3800 ft; depth below the surface (4000 ft); and the actual elevation of the horizon are listed on table 3, 4, and 5. The elevations were posted on a map and faults from regions where there is no current data were transferred from the shallows seismic survey data. A similar procedure was followed for phantoms constructed on a shallow event and a band of deep energy. (Tables 9, 10, 11, 12, 13, 14)

TABLE 1

Soda Lake Unconformity Two-Way Travel Time

Line	Shot Point	TWTT Milliseconds	Correct TWTT
Cs 77-1	1	214	Same (No correction)
	5	223	"
	10	228	"
	15	221	"
	20	224	"
	24	223	"
	25	222	"
	30	230	"
	35	No Record	"
	40	219	"
	45	223	"
	50	240	"
	54	245	"
	55	245	"
	CS-77-3	1	330
4		319	
10		301	
15		289	
20		273	
25		273	
27		250	
30		250	
35		264	fault shadow
40		230	
42		218	
45		210	
47		210	
50		189	
53		191	on fault
55		189	
60		181	
65		171	
70		165	
72		158	
75	155		
80	132		
82	132		

Table II

Soda Lake Unconformity

Line CS-77-2 +15	Shot Point	TWTT Milliseconds	Correct TWTT +15
	1	183	198
	4	190	215
	5	190	215
	10	207	223
	15	211	226
	19 bad point	212	227
	20	209	224
	22 no layer		
	24 no layer		
	25 no layer		
	30	187	202
	32	189	204
	35	197	212
	40 fault zone	190	205
	42	202	217
	52	211	226
	55	219	234
	60	233	248
	65	256	271
	70	227	242
	75	227	242
	78	230	245
	80	231	246
	85	239	254
	90	250	265
	95	249	264
	100	251	266
	105	249	264
	108	248	263
	110	250	265
	115	250	265

TABLE III

Soda Lake Unconformity
Line CS-77-2

Shot Point	One Way Time milliseconds	(+.033) Surface Corrected	Below Surface (Ft.)	Elevation (Ft.)	Posted
1	99	132	879	3121	3120
4	107	140	950	3050	3050
5	107	140	950	3050	3050
<u>10</u>	111	144	986	3014	3015
<u>15</u>	113	146	1004	2996	2995
19	113	146	1004	2996	2995
22					
24					
<u>25</u>					
<u>30</u>	101	134	896	3104	3105
32	102	135	906	3094	3095
35	106	139	941	3059	3060
40	102	135	906	3094	3095
42	108	141	959	3041	3040
<u>52</u>	113	146	1004	2996	2995
<u>55</u>	117	150	1041	2959	2950
60	124	157	1107	2893	2895
<u>65</u>	135	168	1216	2784	2785
<u>70</u>	121	154	1079	2921	2920
75	121	154	1079	2921	2920
78	122	155	1088	2912	2910
80	123	156	1098	2902	2900
85	127	160	1137	2863	2865
90	132	165	1186	2814	2815
95	132	165	1186	2814	2815
100	132	165	1186	2814	2815
105	132	165	1186	2814	2815
108	131	164	1176	2824	2825
110	132	165	1184	2816	2815
115	132	165	1184	2816	2815

TABLE IV

Soda Lake Unconformity
Line CS-77-3

Shot Point	One Way Time milliseconds	(+.033) Surface Corrected	Below Surface (Ft.)	Elevation (Ft.)	Posted
1	165	198	1510	2490	2490
4	160	193	1460	2540	2540
10	150	183	1360	2640	2640
15	144	177	1300	2700	2700
20	136	169	1225	2775	2775
25	136	169	1225	2775	2775
27	125	158	1117	2883	2880
30	125	158	1117	2883	2880
35	132	165	1186	2814	2915
40	115	148	1022	2978	2980
42	109	142	968	3032	3030
45	105	138	932	3068	3070
47	105	138	932	3068	3070
50	94	127	837	3163	3165
53	95	128	845	3155	3155
55	94	127	837	3163	3165
60	90	123	803	3197	3195
65	85	118	761	3239	3240
72	79	112	713	3287	3285
75	77	110	697	3303	3305
80	66	99	612	3388	3390
82	66	99	612	3388	3390

Values Greater than .167

	sec	pt/sec	pt	+ 1200'	= Depth
177 - 167	= .010	x 10,000	= 100	+ 1200	= 1300
183 - 167	= .016	x 10,000	= 160	+ 1200	= 1360
193 - 167	= .026	x 10,000	= 260	+ 1200	= 1460
198 - 167	= .031	x 10,000	= 310	+ 1200	= 1510

TABLE V

Soda Lake Unconformity
Line CS-77-1

Shot Point	One Way Time milliseconds	(+.033) Surface Corrected	Below Surface (Ft.)	Elevation (Ft.)	Posted
1	107	140	949	3051	3050
5	111	144	986	3014	3015
<u>10</u>	114	147	1013	2987	2990
<u>15</u>	110	143	977	3023	3025
<u>20</u>	112	145	995	3005	3005
<u>24</u>	109	142	968	3032	3030
25	111	144	986	3014	3015
30	<u>115</u>	148	1023	2977	2975
35	<u>109</u>	142	968	3032	3030
40	109	142	968	3032	3030
45	111	144	986	3014	3015
50	120	153	1069	2931	2930
54	122	155	1080	2912	2910
55	122	155	1088	2912	2910

TABLE VI

Two Way Travel Times
Line CS-77-1
Soda Lake

Shot Point	Time to Shallow "Phantom" milliseconds	Time to Bedrock milliseconds
1	90	585
5	108	628
9	112	640
13	112	613
13+3 Traces Fault	116	
13+7 Traces	100	
17	102	584
21	108	549
21+11 Traces Fault	108	530
25	113	535
29	113	568
29+15 Traces	115	Sta. 29+08 618
40	104	
44	110	
49	109	
53	109	

TABLE VII

Two Way Travel Times
Line CS-77-2
Soda Lakes

Shot Point	Shallow "Phantom" Time milliseconds	Bedrock Time milliseconds
1	83	492
5	88	495
5+12 Traces	94	500
Fault		
10	93	506
15	90	521
20	89	542
20+29 Traces	62	593
30	60	609
32	64	614
35	60	623
40	58	653
40+19 Traces	68	677
40+40 Traces	78	708
55	91	735
60	105	771
65	110	810
65+08 Traces	118	821
Fault		
65+11 Traces	81	827
70	83	840
75	81	871
78	83	888
80	84	898
85	83	920
90	81	948
95	91	961
100	89	970
105	89	987
108	84	991
110	88	995
115	103	998

TABLE VIII

Two Way Travel Times
 Line CS-77-3
 Soda Lake Upper "Phantom" and Bedrock

Shot Point	Shallow "Phantom" Time milliseconds	Bedrock Time milliseconds
1	112	930
4	115	896
10	112	829
17	112	788
Fault		
18	107	747
19	104	741
25	108	683
26	110	
Fault		Sta. 27 658
28	95	
30	93	632
35	95	640
		Sta. 37 659
39	91	
Fault		
41	73	
42	71	
45	69	
47	75	
50	67	
51	62	
Fault		
52	50	
53	50	1135
55	47	1100
60	48	1060
65	42	1045
70	32	1056
72	33	1062
74	49	
75	51	1075
80	41	1125
82	32	1145

TABLE IX

CS-77-2
Shallow "Phantom"

Spot Point	One Way Time milliseconds	(+.033) Surface Corrected	Below Surface (Ft.)	Elevation (Ft.)	Posted
1	41	74	433	3567	3565
5	44	77	454	3546	3545
8	47	80	474	3526	3525
10	46	79	467	3533	3535
15	45	78	460	3540	3540
20	44	77	454	3546	3545
27	31	64	366	3634	3635
39	30	63	360	3640	3640
32	32	65	373	3627	3625
35	30	63	360	3640	3640
40	29	62	353	3647	3645
45	34	67	386	3614	3615
50	39	72	420	3580	3580
55	45	78	461	3539	3549
60	52	85	510	3490	3490
65	55	88	531	3469	3470
67	59	92	560	3440	3400
68	40	73	426	3570	3570
70	41	74	433	3567	3570
75	40	73	426	3574	3575
78	41	74	433	3567	3565
80	42	75	440	3560	3560
85	41	74	433	3567	3565
90	40	73	426	3574	3575
95	45	78	461	3539	3540
100	44	77	454	3546	3545
105	44	77	454	3546	3545
108	42	75	440	3560	3560
110	44	77	454	3546	3545
115	51	84	503	3497	3500

TABLE X
 CS-77-1
 Shallow "Phantom"

Shot Point	One Way Time milliseconds	(+.033) Surface Corrected	Below Surface (Ft.)	Elevation (Ft.)	Posted
1	45	78	470	3530	3530
5	54	87	524	3476	3475
9	56	89	539	3461	3460
13	56	89	539	3461	3460
14	58	91	553	3447	3450
15	50	83	495	3505	3505
17	51	84	503	3497	3500
21	54	87	524	3476	3475
24	54	87	524	3476	3475
25	56	89	538	3462	3460
29	56	89	538	3462	3460
33	57	90	546	3454	3455
40	52	85	510	3490	3490
44	55	88	531	3469	3470
49	54	87	524	3476	3475
53	54	87	524	3476	3475

TABLE XI

CS-77-3
Shallow "Phantom"

Shot Point	One Way Time milliseconds	(+.033) Surface Corrected	Below Surface (Ft.)	Elevation (Ft.)	Posted
1	56	89	539	3451	3460
4	57	90	546	3454	3455
10	56	89	539	3461	3460
17	56	89	539	3461	3460
18	53	86	517	3483	3485
19	52	85	510	3490	3490
25	54	87	524	3476	3475
26	55	88	531	3469	3479
28	47	80	474	3526	3525
30	46	79	468	3532	3530
35	47	60	474	3526	3525
39	45	78	461	3539	3549
41	36	69	400	3600	3600
42	35	68	393	3607	3605
45	34	67	386	3614	3615
47	37	70	406	3594	3595
50	33	66	380	3620	3620
51	31	64	367	3633	3635
52	25	58	328	3672	3670
53	25	58	328	3672	3670
55	23	56	315	3685	3685
69	24	57	322	3678	3680
65	21	54	303	3697	3709
70	16	49	272	3728	3730
74	24	57	322	3678	3680
75	25	58	328	3672	3670
80	20	53	296	3704	3705
82	16	49	272	3728	3730

TABLE XII

CS-77-1
Basement "Phantom"

Shot Point	One Way Time (Mils)	Surface Corrected (+.033) (Mils)	Time to 1200' (-.167) (Mils)	(cx10,000) Depth Below 2800'	(+1200') Depth Below Surface	Elevation Above Sea Level
1	292	325	158	1580	2780	1220
5	314	347	180	1800	3000	1000
9	320	353	186	1860	3060	940
13	306	339	172	1720	2920	1080
14						
15						
17	292	325	158	1580	2780	1220
21	274	307	140	1400	2600	1400
24	265	298	131	1310	2510	1490
25	267	300	133	1330	2530	1470
29	284	317	150	1500	2700	1300
33	309	342	175	1750	2950	1050
40						
44						
49						
53						

TABLE XIII

CS-77-2
Basement "Phantom"

Shot Point	One Way Time (Mils)	Surface Corrected (+.033) (Mils)	Time to 1200' (-.167) (Mils)	(cx10,000) Depth Below 2800'	(+1200') Depth Below Surface	Elevation
1	246	279	112	1120	2320	1680
5	247	280	113	1130	2330	1670
8	250	283	116	1160	2360	1640
10	253	286	119	1190	2390	1610
15	230	263	116	1160	2360	1640
20	271	304	137	1370	2570	1430
27	196	329	162	1620	2820	1180
30	304	337	170	1700	2900	1100
32	307	340	173	1730	2930	1070
35	311	344	177	1770	2970	1030
40	326	359	192	1920	3120	880
45	338	371	204	2040	3240	760
50	354	387	220	2200	3400	600
55	367	400	233	2330	3530	470
60	405	428	261	2610	3810	190
65	405	438	271	2719	3910	90
67	410	443	276	2760	3960	40
68	413	446	279	2790	3990	10
70	420	453	286	2860	4060	-60
75	435	468	301	3010	4210	-210
78	444	477	310	3100	4300	-300
80	449	482	315	3150	4350	-350
85	460	493	326	3260	4460	-460
90	474	507	340	3400	4600	-600
95	480	513	346	3460	4660	-660
100	485	518	351	3510	4710	-710
105	493	526	359	3590	4790	-790
108	495	528	363	3630	4830	-830
110	497	530	363	3630	4830	-830
115	499	532	365	3650	4850	-850

TABLE XIV

CS-77-3
Basement "Phantom"

Shot Point	One Way Time (Mils)	Surface Corrected (+.033) (Mils)	Time to 1200' (-.167) (Mils)	(cx10,000) Depth Below 2800'	(+1200') Depth Below Surface	Elevation
1	465	498	331	3310	4510	-510
4	448	481	314	3140	4340	-340
10	414	447	380	2800	4000	-0
17	394	427	360	2600	3800	+200
18	373	406	339	2390	2590	-410
19	370	403	336	2360	3560	+440
25	341	374	207	2070	3270	+730
26						
28	329	362	195	1950	3150	+850
30	316	349	182	1820	3020	+980
35	320	353	186	1860	3060	+940
39	329	362	195	1950	3150	+850
41						
42						
45						
47						
50						
51						
52						
53	567	600	433	4330	5530	-1530
55	550	583	416	4160	5360	-1360
60	530	563	396	3960	5160	-1160
65	522	555	388	3880	5080	-1080
70	528	561	394	3940	5140	-1140
72	531	564	397	3970	5170	-1170
74						
75	537	570	403	4030	5230	-1230
80	563	596	429	4290	5490	-1490
82	572	605	438	4380	5580	-1580