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BEOWAWE AREA SHALLOW SEISMIC REFLECTION SURVEY

LANDER COUNTY, NEVADA

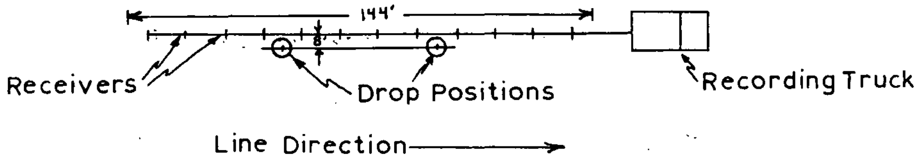
I. Introduction

During the period from May 13 through September 1, 1975, a shallow seismic reflection survey was carried out in the southwest part of the Whirlwind Valley, Lander County, Nevada, near the small town of Beowawe (see Figure No. 1, Location Map). Approximately 17.5 miles of data were recorded, consisting of four northeast-southwest lines (Lines BW-1 through BW-4) and four northwest-southeast lines (Lines BW-5 through BW-8). The purpose of the survey was to investigate the geologic structure, especially faulting, as an aid to continued exploration for geothermal steam in the area.

II. Technique

Line positions in the field were established by reference to topographic features, as the magnetic compass tended to be sometimes erratic in the presence of so much magnetite-bearing ? lava. After the position of a given line was established, stations were located along it at intervals of 165 ft. (50M) by chaining with a measured drag rope 165 feet long. Difficult terrain made it necessary for parts of lines BW-3, BW-6 and BW-7 to depart from the program positions.

The seismic source used for the first two lines recorded (Line BW-1 and Line BW-6) was a 300 lb. steel weight dropped free-fall a distance of 3½ feet for approximately 1000 ft. lbs. of energy per drop. Three drops per station on the average were made and summed in the field. Detection was by means of a receiver array of 12 digital grade 10 Hz geophones inline spaced 12 feet apart. Where possible, the source weight was dropped one or two times at each of two locations beside the one-third positions of the receiver array and offset about 8 feet laterally (see sketch below).



Recording was done by a Seaman Nuclear Corporation engineering type single-channel seismograph (with summing digital memory) modified to include frequency filters, programmed gain expansion, a paper strip chart recorder, and a magnetic cassette digital recorder. A recording length of 0.5 second after weight impact was used. As successive drops were recorded at each station, the summed results were viewed by the operator on a cathode ray tube. When the operator judged that enough thumps had been recorded (the number varied from one to six) the summed data were recorded on paper and magnetic tape and the crew moved on to the next station.

During the recording of BW-1 and BW-6 it became evident that though the data in the top 1,000 feet were good, the rate of energy decay with depth was unusually great. As a result, the operation was suspended in late May and the equipment returned to Albuquerque for modifications. A new and larger weight drop system using a 700 pound steel weight which could be dropped as much as 6½ feet was built, and the type of programmed gain expansion was changed to allow far greater range in rate of gain increase with time. When the modifications were complete and field-tested, the crew returned to the Beowawe area, renewing work July 21, 1975. The remaining lines of the project (BW-2 through BW-5 and BW-7 through BW-8) were recorded dropping the 700 lb. weight about 5 3/4 feet free-fall for about 4000 ft. lbs. of energy per drop. This increased source energy plus the improved available gain increase allowed the recording of 1.0 second as opposed to the previous 0.5 second. Practical depth of penetration was increased from about 1,000 feet to about 2,500-3,000 feet, which considerably improved ability to detect faults. The change, however, was not all favourable; the quality of data in the top 1,000 feet was noticeable reduced, as shown by a comparison recorded on Line BW-1. Consequently, after completion of the Beowawe survey and before initiation of the next (Hot Springs Point) survey, experimental work was done in an attempt to find an energy input level which would provide penetration deeper than 1,000 feet but without sacrificing detail or quality in the top 1,000 feet. In this expeimentation it was found that dropping the 700 lb. weight 3½ feet (for about 2,500 ft. lbs. of energy) greatly improved the data in the top 1,000 feet while sacrificing little in the way of depth penetration. It is therefore recommended that in any future shallow reflection work in the Beowawe area this level of energy input be used.

After each day's field work, the records made during the day were corrected to a reference plane of +5000 feet using a correction velocity of 3,000 feet per second (determined at the start of the survey by refraction probes recorded on Line BW-1 near the Chevron Ginn No. 1-13 well). The paper records were then colored, trimmed and combined to form corrected variable area/wiggle trace record sections (see Enclosures Nos. 1 through 8). These record sections were then studied and picked, with an attempt being made to recognize both reflections and diffractions, the latter for their value in fault detection (see Enclosures Nos. 9 through 16). The timed events were then converted to depth using a velocity function fitted to the pseudo-sonic log data from the Chevron Ginn No. 1-13 well, located within the prospect (see Table No. 1). Migrated depth sections were next made using the point-arc method (see Enclosures Nos. 17 through 24). In this method, which is well suited to shallow single-channel recording, for each event picked on the record section a circular arc is swung from each station at which the event is picked. This arc has its center at the station position (at reference plane elevation) and its radius equal to the depth calculated for the event at that station. A curve is then drawn tangent to each of the arcs representing a given event at successive stations. If the velocity function is accurate such curves are a good representation of the corresponding reflectors. In cases where three or more arcs from a single event intersect at a single point, the event is probably a diffraction. Such apparent diffraction centers are indicated on the migrated sections and are often helpful in fault interpretation.

After completion of field recording in the Beowawe area, the locations of 12 of the 16 line intersections were determined by plane-table triangulation from three known positions (see map, Enclosure No. 25). In cases where a given point could be shot from all three triangulation stations, the apparent error indicated was less than 30 feet, so that these intersections can be regarded as very accurately located. The four intersections involving Line BW-4, unfortunately, could not be shot in from the triangulation stations, and are consequently less certain in location. However, even these are probably actually located within 100-200 feet of their mapped positions.

III. Results

The seismic results obtained in the Beowawe area are generally of poor quality. Experience elsewhere, however, suggests that in this complexly-faulted area the data are almost certainly superior to data which might be obtained by more conventional seismic techniques. In hindsight, it appears that the improvement gained by using 50 meter (165 feet) spacing rather than 100 meter (330 feet) spacing as in other prospects was probably not worth the additional cost (almost twice as much per mile). However, the Beowawe area, because of its complexity, was a particularly good test example to determine if the closer spacing is worth the additional cost in exploration of this type.

The writer's interpretation of the structure of the project area is shown by the Structure Contour Map, Enclosure No. 25. This map is drawn on a seismic phantom which it is hoped may be at approximately the same stratigraphic position throughout the area. Because of the difficulty of correlating from one fault block to another, however, the likelihood of its being the same horizon everywhere is not good. The general structural form shown, however, is probably reasonably accurate.

Folding in general appears to be of much less importance than faulting. Only one fold, the east-plunging anticlinal nose in Section 14, seems to suggest that it may have formed independently of and prior to the present fault system. ?

Only faults judged to be of importance are shown. Many lesser faults are indicated by the seismic data. The faults considered to be of greatest significance are those shown on the map by heavier green lines. Two faults in particular are believed worthy of notice. These are (1) the arcuate fault at the foot of the Malpais Range (extreme southeast margin of the survey area) and (2) the opposing subparallel fault near the northwest edge of the survey area (and cutting Line BW-1 at Stations 55-56). Between these two major faults there appears to be a significant graben trending northeast-southwest and creating the smaller southwest extension of Whirlwind Valley which is the survey area. About 2/3 of a mile northwest of the main Malpais Range frontal fault is another fault set, also down to the northwest. Between these step faults and the main Malpais Range frontal fault is a fault block intermediate in depth between the valley graben and the Malpais Range. Its most obvious manifestation is the large hill in the south half of Section 18. The remaining fault considered of major importance crosses the valley graben north-northwesterly in the east half of section 13. This fault may not be of great throw, but it does appear to mark a major dip reversal in the graben and cause the northwest quarter of Section 13 to be the lowest point in the graben. It (the fault) was probably penetrated at shallow depth in the Chevron Ginn 1-13 well (SE/SE Sec. 13).

A few faults are shown which are not believed to be of great importance, at least in the survey area proper. Of particular interest is a set of faults encountered along the northeast side of the survey. These faults appear to strike a few degrees north of east and evidently die out westward near the position of Line BW-2. Those faults of this set which lie southeast of the center of the southeast quarter of Section 12 are apparently downthrown to the north; those farther northwest are apparently downthrown to the south. It seems likely that these faults are the west ends of a step fault system forming the main Whirlwind Valley graben to the east. If this is true, it would appear that the deepest downthrown part of the main Whirlwind Valley graben to the east lies about 3/4 of a mile north of the Malpais Range front, making the Whirlwind Valley graben highly assymetric.

Seismic evidence regarding the attitudes of the major faults in the survey area can be seen in several places. On Lines BW-1 and BW-4, the main Malpais Range frontal fault appears to dip about 70 degrees northwest (corrected for line angle on BW-4). The large step fault system about 2/3 mile northwest of the main Malpais Range frontal fault evidently dips about 60 degrees northwest on Line BW-2, and about 75 degrees on Lines BW-1, BW-3, and BW-4. The large cross-graben fault in the east half of Section 13 is apparently nearly vertical, but does dip southeast, as seen on Lines BW-1, BW-6, and BW-7. The large fault on the northwest side of the survey area graben also appears to be nearly vertical but does evidently dip southeast (see Line BW-2 especially). In summary, all the major faults appear to be normal faults, with dips ranging from about 60 degrees to nearly vertical. Only one or two doubtful cases of possible minor high-angle reverse faults were observed.

On some of the seismic lines the nearest reflector to the mapped phantom shows a large number of diffraction points (see especially Lines BW-2 and BW-8). This may indicate that the horizon is an unconformity with a great deal of irregularity (not strange in a volcanic sequence) or is perhaps a thick, competent unit subject to a great deal of small faulting and fracturing.

IV. Conclusions

A. The survey area appears to be basically a smaller graben extending southwestward from the main Whirlwind Valley graben.
B. Folding in the area seems to be very minor compared to faulting.
C. All the major faults as interpreted are evidently normal faults, with dips in the range from 60 degrees to nearly vertical.
D. The seismic reflection method seems to be clearly applicable to exploration of this type, despite the complex faulting present.

V. Recommendations

A. To penetrate the main Malpais Range frontal fault at about 4000 ft. depth, wells should be located on the downthrown side about 1200 feet from the fault as mapped.

B. In future investigations of this type, close station spacing (165 feet or 50M) should be reserved for cases where increased detail is needed, and normal station spacing (330 feet or 100M) should be the standard, for reasons of economy.

Respectfully submitted,

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1 Figure
1 Table
25 Enclosures

RAND McNALLY
STATE COUNTY-CITY MAP

NEVADA
SIZE 8½ x 11

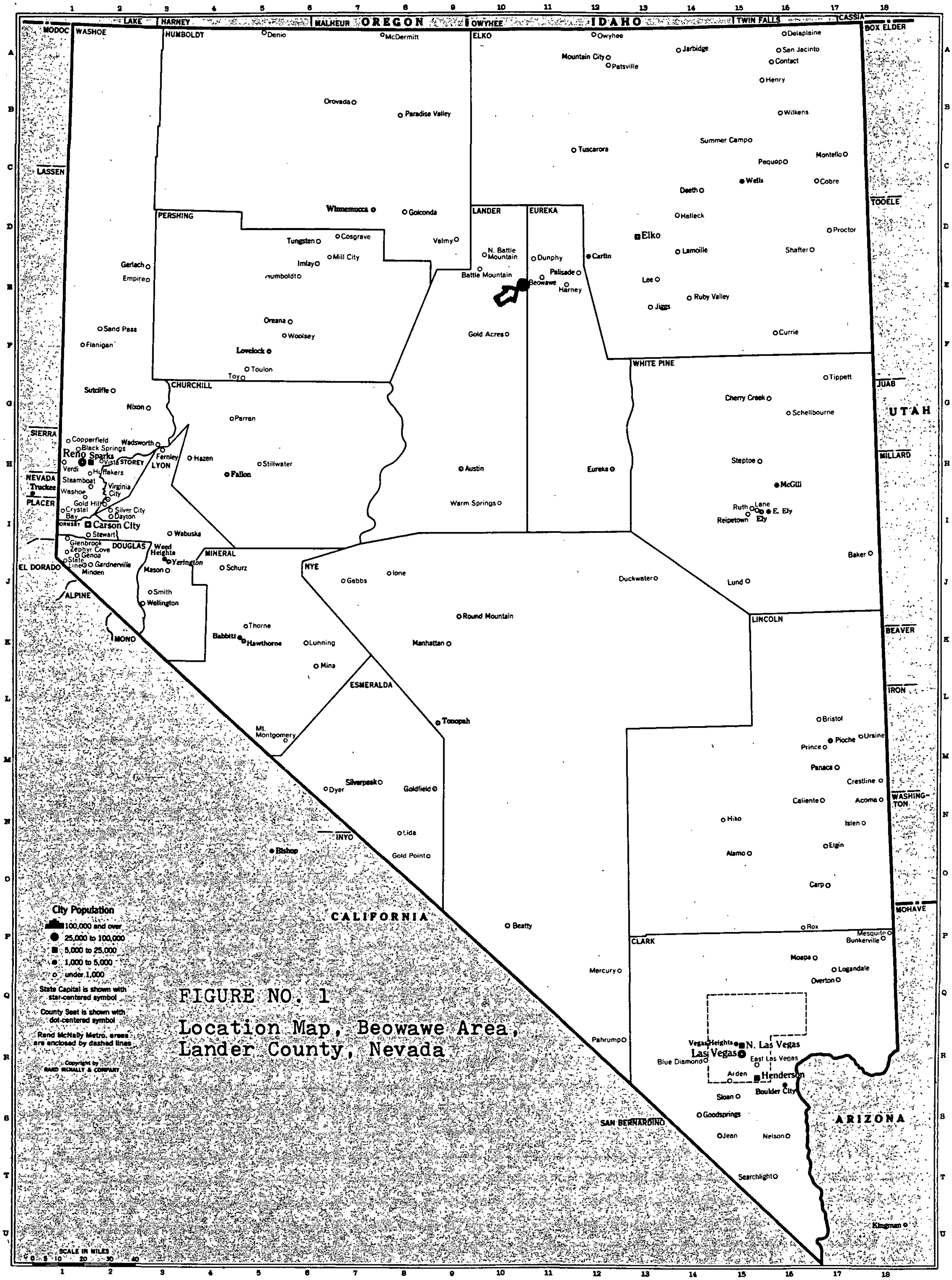

FIGURE NO. 1
Location Map, Beowawe Area,
Lander County, Nevada

This Map is also available with County Outlines only.

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CHEVRON GINN 1-13 VELOCITY FUNCTION

LANDER COUNTY, NEVADA

$Vi = 2000 + 10.0Z$ $Z<750'$ Breakover time 0.312

$Vi = 8000 + 2.0Z$ $Z\geq 750'$ Breakover time 0.172

(Accurate only to 4200' depth) Datum +5000'

(T=one-way time)

(two-way) Time	ft/ms	(feet) Depth	(two-way) Time	ft/ms	(feet) Depth	(two-way) Time	ft/ms	(feet) Depth
0.005		5	0.200		344	0.385		1110
0.010		10	0.205		357	0.390		1135
0.015		16	0.210		371	0.395		1161
0.020		21	0.215	3	386	0.400		1187
0.025		27	0.220		401	0.405		1213
0.030		32	0.225		416	0.410		1239
0.035	1	38	0.230		432	0.415		1265
0.040		44	0.235		448	0.420	5	1292
0.045		50	0.240		464	0.425		1318
0.050		57	0.245		481	0.430		1345
0.055		63	0.250		493	0.435		1372
0.060		70	0.255		516	0.440		1399
0.065		77	0.260		534	0.445		1426
0.070		84	0.265		552	0.450		1453
0.075		91	0.270		571	0.455		1480
0.080		98	0.275	4	591	0.460		1508
0.085		106	0.280		611	0.465		1535
0.090		114	0.285		631	0.470		1563
0.095		122	0.290		653	0.475		1591
0.100		130	0.295		674	0.480		1619
0.105		138	0.300		696	0.485		1647
0.110		147	0.305	5	719	0.490		1675
0.115		155	0.310		742	0.495		1704
0.120		164	breakover			0.500		1732
0.125	2	174	0.312		750	0.505		1761
0.130		183	0.315		764	0.510		1790
0.135		193	0.320		788	0.515	6	1819
0.140		203	0.325		812	0.520		1848
0.145		212	0.330		836	0.525		1877
0.150		223	0.335		861	0.530		1907
0.155		234	0.340		885	0.535		1937
0.160		245	0.345		909	0.540		1966
0.165		256	0.350	5	934	0.545		1996
0.170		268	0.355		959	0.550		2026
0.175		280	0.360		984	0.555		2057
0.180		292	0.365		1009	0.560		2087
0.185		304	0.370		1034	0.565		2117
0.190		317	0.375		1059	0.570		2148
0.195		330	0.380		1084	0.575		2179

(two-way) Time	ft/ms	(feet) Depth
0.580		2210
0.585		2241
0.590	6	2272
0.595		2304
0.600		2335
0.605		2367
0.610		2399
0.615		2432
0.620		2463
0.625		2496
0.630		2528
0.635		2561
0.640		2594
0.645		2627
0.650		2660
0.655		2693
0.660		2727
0.665		2761
0.670		2795
0.675	7	2829
0.680		2863
0.685		2897
0.690		2932
0.695		2967
0.700		3002
0.705		3037
0.710		3072
0.715		3107
0.720		3143
0.725		3170
0.730		3215
0.735		3251
0.740		3287
0.745		3324
0.750		3361
0.755		3397
0.760		3435
0.765		3472
0.770		3509
0.775		3547
0.780		3585
0.785		3623
0.790		3661
0.795		3699
0.800		3738
0.805	8	3777
0.810		3816
0.815		3855
0.820		3894
0.825		3934
0.830		3974
0.835		4014
0.840		4054
0.845		4094
0.850		4135
0.855	8	4175
0.860		4216
0.865		4258
0.870		4299
0.875		4341
0.880		4382
0.885		4425
0.890		4467
0.895		4509
0.900		4552
0.905		4595
0.910		4638
0.915		4681
0.920		4725
0.925		4768
0.930		4812
0.935	9	4856
0.940		4901
0.945		4945
0.950		4990
0.955		5035
0.960		5081
0.965		5126
0.970		5172
0.975		5218
0.980		5264
0.985		5310
0.990		5357
0.995		5404
1.000		5451

CHEVRON GINN 1-13 VELOCITY FUNCTION

August 18, 1975

Charles B. Reynolds & Associates