UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

LANDSAT LINEAR FEATURE DATA OF THE GALLUP-GRANTS URANIUM DISTRICT, NEW MEXICO

by

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Introduction

The purpose of this report is to present linear feature data mapped from computer-enhanced Landsat images of the Gallup-Grants uranium district, northwest New Mexico (fig. 1), and to demonstrate how the linear feature data are acquired and analyzed for length, preferred orientation, and spatial distribution characteristics. The results of the analyses could then be be integrated with other geological, geophysical, and geochemical data to evaluate the geologic significance of the linear features and their regional patterns.

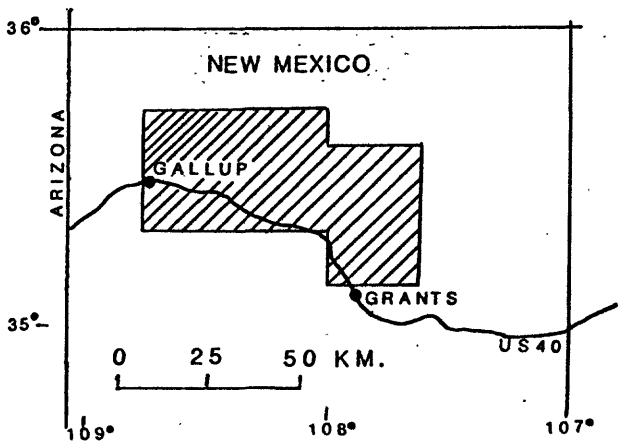

Figure 1. Index map showing location of study area.

Landsat Data

The two sets of Landsat images, that were used in the linear feature mapping, were prepared from the digital data by the U.S. Geological Survey EROS Data Center, Sioux Falls, South Dakota. Digital image-enhancement techniques were applied to the primary image data (landsat scene 5181-16512) to correct for six-line banding, geometric and radiometric distortion, and line dropouts. Contrast on the image was enhanced at the EROS Data Center by stretching and edge enhancement techniques as described in Sabins (1978). Black and white images of each of the four multispectral scanner system (MSS) bands and a false color infrared composite prepared from MSS bands 4, 5, and 7, all at a scale of 1:1,000,000, were examined for linear features. In addition, interpretation of a 1:250,000-scale print of a false color infrared

composite of scene 1425-17193, scanned in September 1973 shortly after a period of rainfall, was extremely useful for recognizing subtle linear features; these features are expressed primarily by vegetation patterns not observed on the primary set of images.

Linear Features Mapping

Linear features were first identified and mapped on an overlay on the 1:1,000,000-scale images, then transferred to a 1:250,000 topographic map. Most of the linear features are expressed as topographic break in slope or as elongated topographic lows. A few, however, are expressed only by a change of image tone. These tonal features, prominent in the northwest and central parts of the study area were either most prominently expressed or only seen on the false color infrared composite of scene 1425-17193, and may be due to subtle variations in vegetation density enhanced by the period of rainfall shortly before the image was scanned.

Most of the mapped linear features have a single type of surface expression. A few of the linear features, however, are formed by an alinement of linear elements with differing types of image and surface expression. In general, the majority of linear features are topographically expressed and most easily seen on the false color infrared composites and the black and white image of the band 5 data.

The completed map of linear features was digitized for computer analysis. Only the end points of the individual linear features needed to be digitized to accurately reproduce the lines. Figure 2 is a computer-generated plot of the linear features map. Computer plotted linear features typically are straighter than linear features mapped on images.

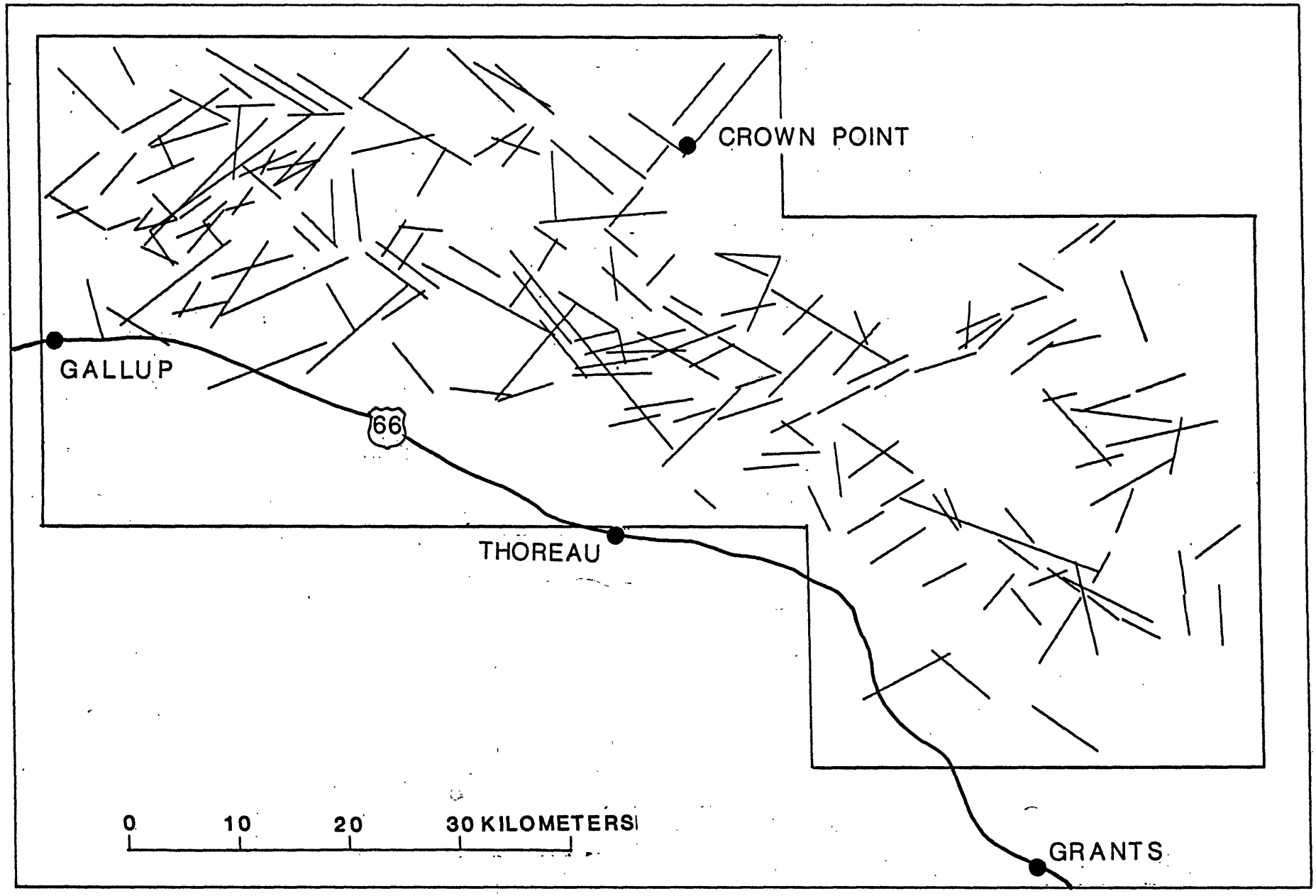

Figure 2.--Mapped linear features of the Gallup-Grants uranium district, N. M..

Characteristics of Linear Feature Data Set

With data sets containing a relatively small number of linear features, it is usually possible to evaluate important trends and patterns by visual examination of the map. As the data sets become larger, they also become more complex, and visual evaluation alone is no longer sufficient. Sawatzky and Raines (1979) describe some analytical techniques for characterizing complex linear feature data sets in terms of lengths and orientation. These techniques have found application in a variety of geologic terrains and are used in this report (Raines, 1978; Raines and others, 1978; Knepper, 1978; 1979). A brief description of these analysis is given below.

Length Frequency Analysis

The length frequency analysis computer program plots a histogram of the length of linear features as a function of their frequency of occurrence (Appendix C). In addition, the following were also calculated in length frequency analysis.

Longest linear feature	17.2 km
Shortest linear features	2.1 km
Mean length	5.25 km
Mode length	4.5 km
Standard deviation	2.5 km

The abrupt minimum length cut off observed in the length frequency histogram is typical of linear feature data mapped from Landsat images (D. H. Knepper, unpublished data). The cutoff is a function of the resolution of the Landsat system (79 meter-square ground resolution), map scale, and the image quality. The number of mapped linear features with lengths greater than the modal length decreases exponentially, producing a histogram with an approximately log normal distribution.

Strike Frequency Analysis

The strike frequency analysis used in this study determines the frequency of occurrence of linear features in each of the 180 one-degree azimuthal classes. The significance value of a given frequency of occurrence is based on the probability of that frequency occurring in a given data set with a uniform population of directions (Raines, 1978). Low significance values occur when the frequency is near the mean frequency. Higher significance values occur as the frequency of occurrence deviates from the mean value.

In the length weighted strike-frequency analysis, each linear feature is weighted proportional to its length. This technique is used to emphasize the potential importance of the longer features and to enhance trends containing these longer linear elements. Computer printouts of the results of the unweighted and length weighted strike frequency analyses can be found in Appendices B and C. The analyses are replotted in figures 3 and 4 to better display the relationship between strike frequency and significance value and to show the degree of preferential orientation in the linear feature data set. In the unweighted analyses (fig. 3), a 90.6 significance value (10 linear features in a one-degree interval) was chosen as indicating a strong preferential orientation. In the length weighted analyses (fig. 4), preferred orientation is similarly indicated when the curve reaches a 94.0 percent significance value.

In the Gallup-Grants data, the unweighted strike frequency analysis shows five narow trend intervals extending above the 90.6 significance value (fig. 3). In the length weighted analysis many peaks are in the significant field (fig. 4). These results are presented in table 1.

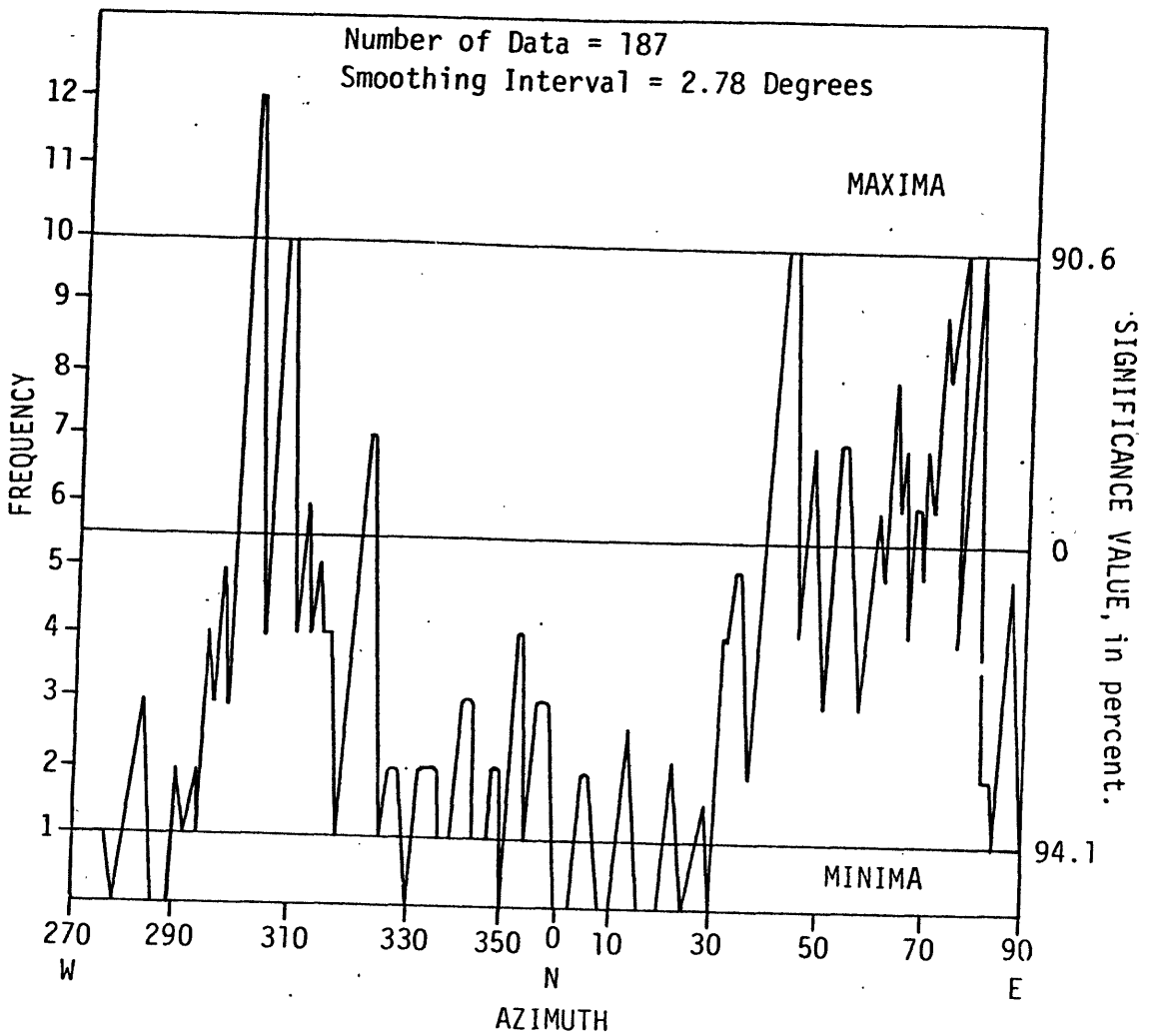

Figure 3.--Unweighted strike-frequency histogram of linear features Gallup-Grants area.

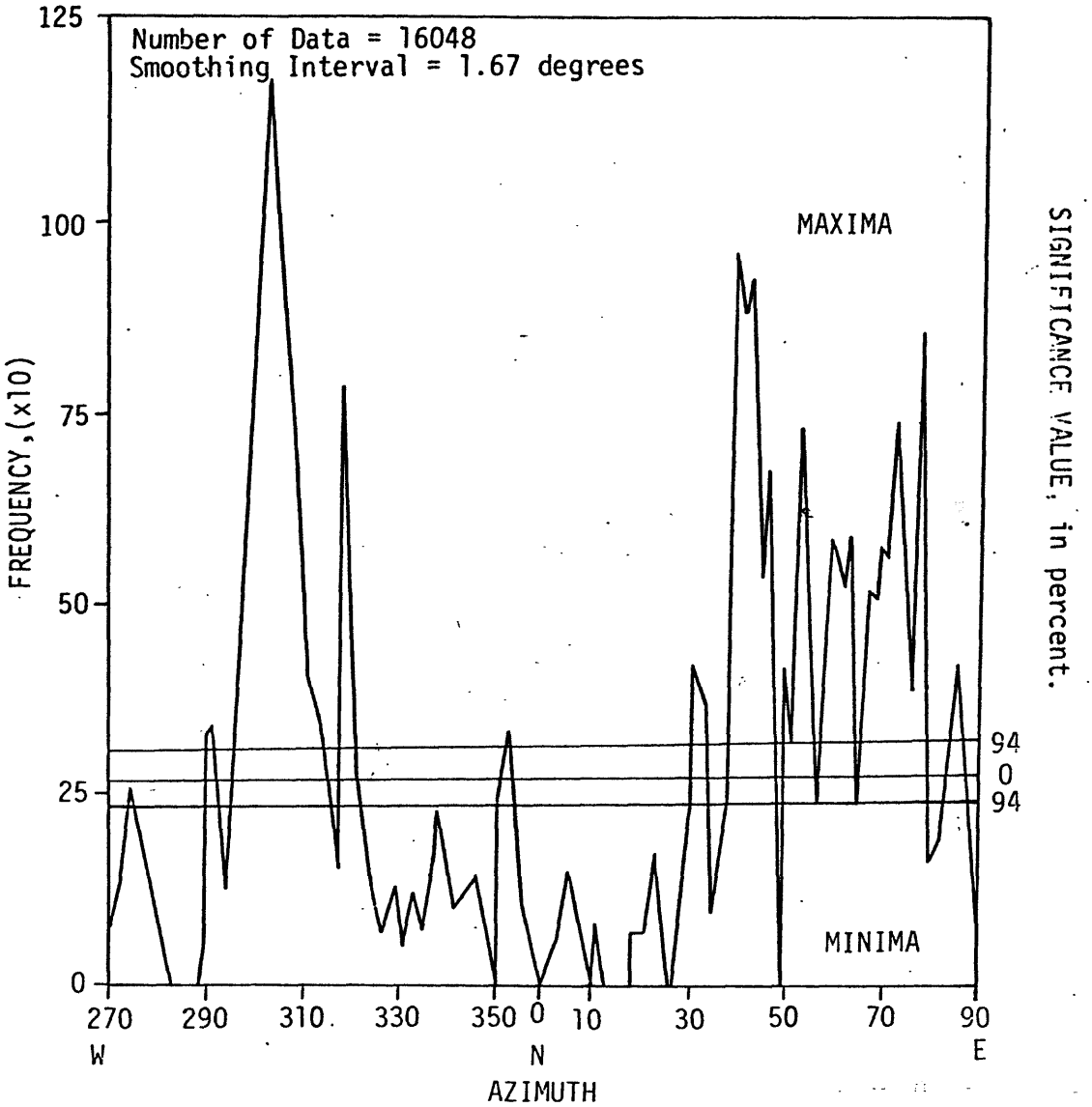

Figure 4 .--Length weighted strike-frequency histogram of the Gallup-Grants area.

Table 1.--Azimuthal trends, of the significant maxima, from the unweighted and length weighted strike-frequency analysis in degrees for the Gallup-Grants Uranium District

Unweighted		Length weighted	
Maxima	Angular width	Maxima	Angular width
301-302	2	290	1
306-307	2	292	1
39- 41	3	296	1
73	1	298-315	18
77	1	320-322	3
		353	1
		32- 34	3
		39- 41	3
		43- 46	4
		49- 56	8
		59- 73	15
		86- 88	3

It is often useful to group the many narrow trend intervals into several broader trend intervals that are characteristic of the region. One method for selecting the maxima points and end points of each of the broader trend intervals was presented by Knepper (1979) and is outlined below.

(1) Significant maxima were chosen by picking only those intervals common to both the length weighted and the unweighted strike frequency analyses.

(2) If a maximum interval is directly adjacent to a minimum, the 1-degree maximum azimuthal trend closest to the adjacent minimum is selected as the end point.

(3) If the maximum is separated from the nearest minimum by a field of non-significant 1-degree trends, the 1-degree azimuthal trend one-half the

angular distance between the minimum and maximum is chosen as end point. If the difference in azimuth is an odd number of degrees, the extra 1-degree of azimuth is included in the maximum interval. Applying this method of trend interval selection to the Gallup-Grants linear feature data resulted in the definition of three relatively broad trend intervals of 34° to 44°, 60° to 80°, and 298° to 312°.

Linear features of any specified trend interval may be easily viewed by means of computer graphics. The computer graphics plot of the desired trend interval may then be visually analyzed for cluster, alinements, or other linear feature distribution patterns which may be suggestive of possible geologic or tectonic conditions. Figures 5 through 7 are computer plots of the linear features contained in broad selected trend intervals in the Gallup-Grants study area.

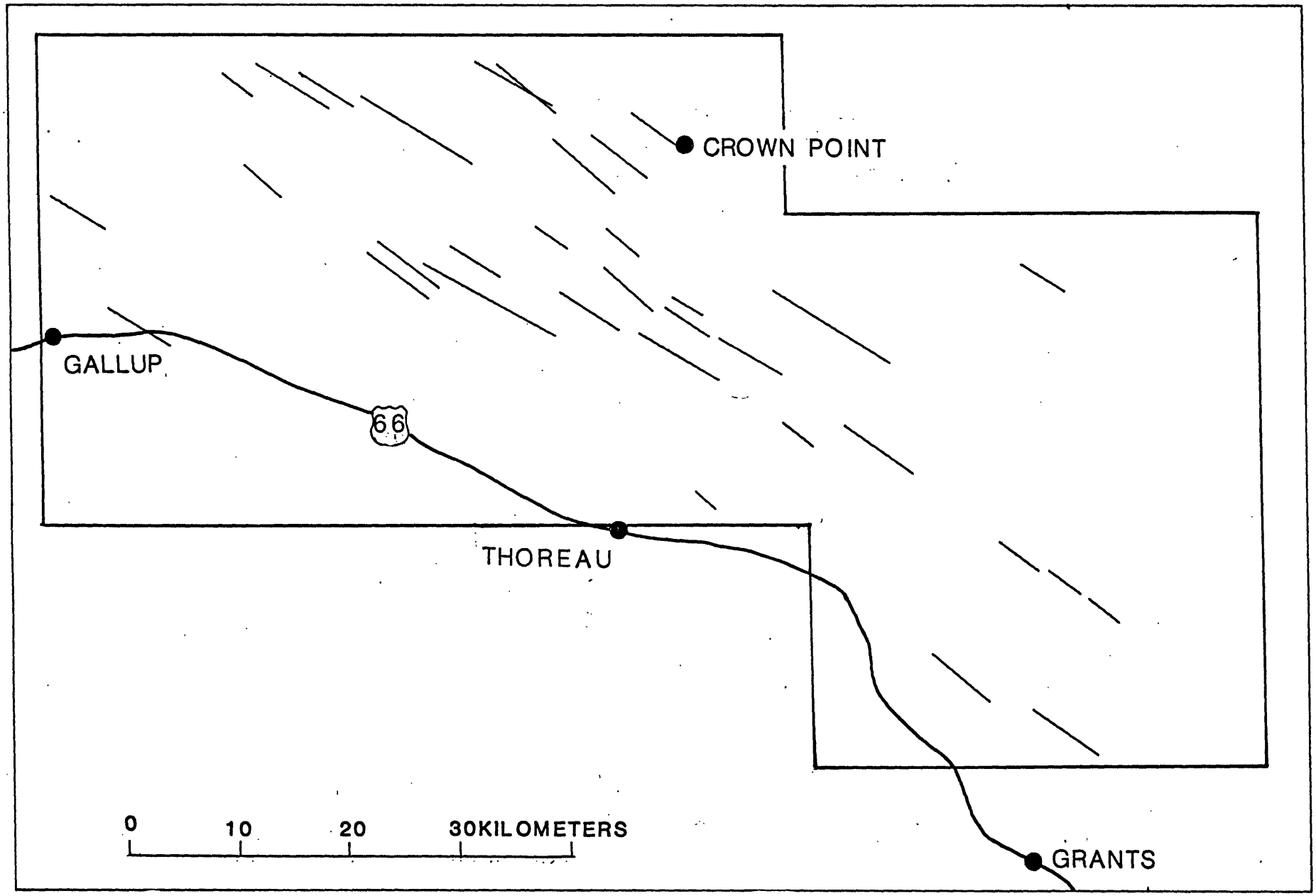

Figure 5.-Linear features of the Gallup-Grants uranium district, N. M..Trend interval is 298°to 312°.

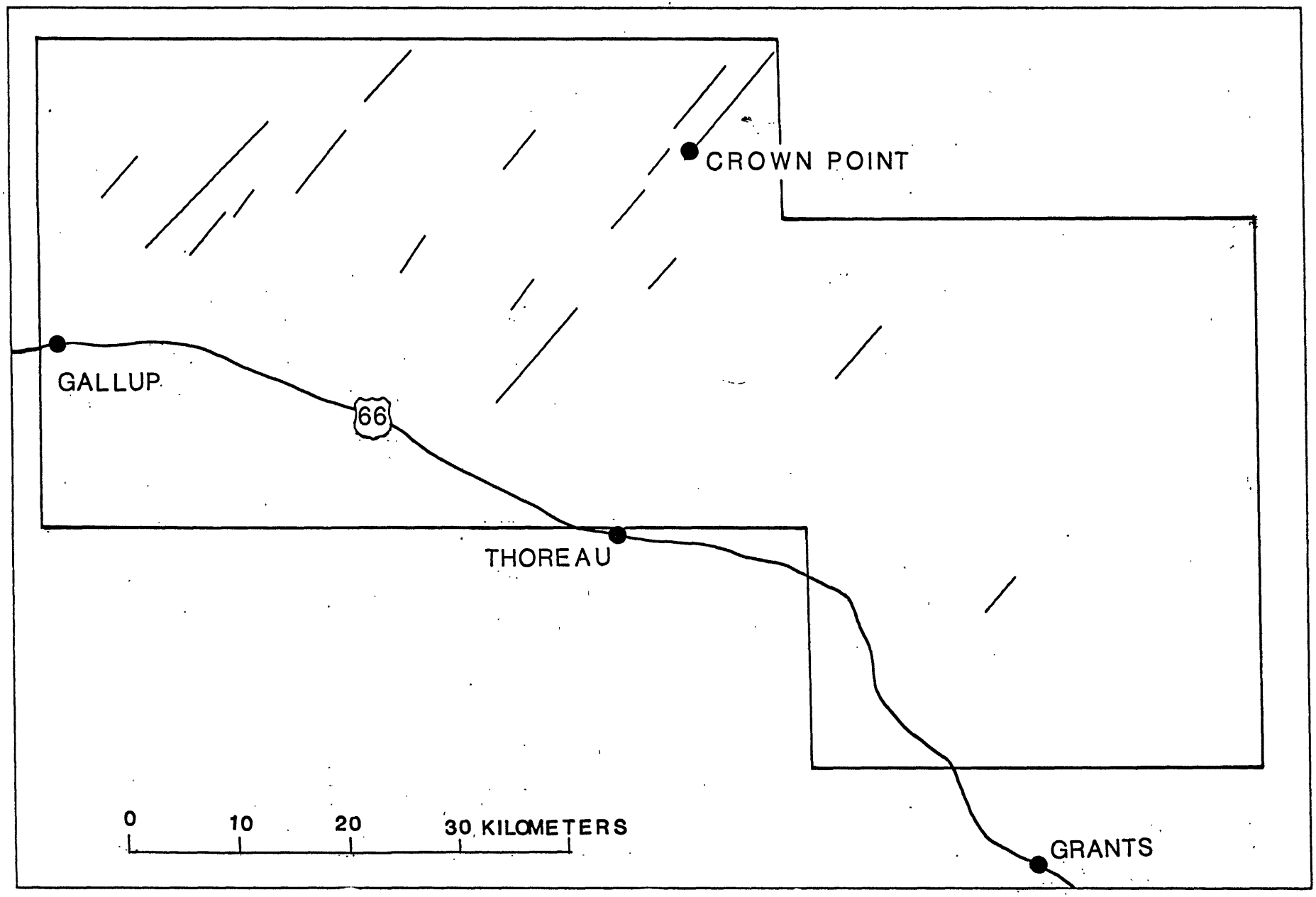

Figure 6.-Linear features of the Gallup-Grants uranium district, N. M..Trend interval is 34°to 44°.

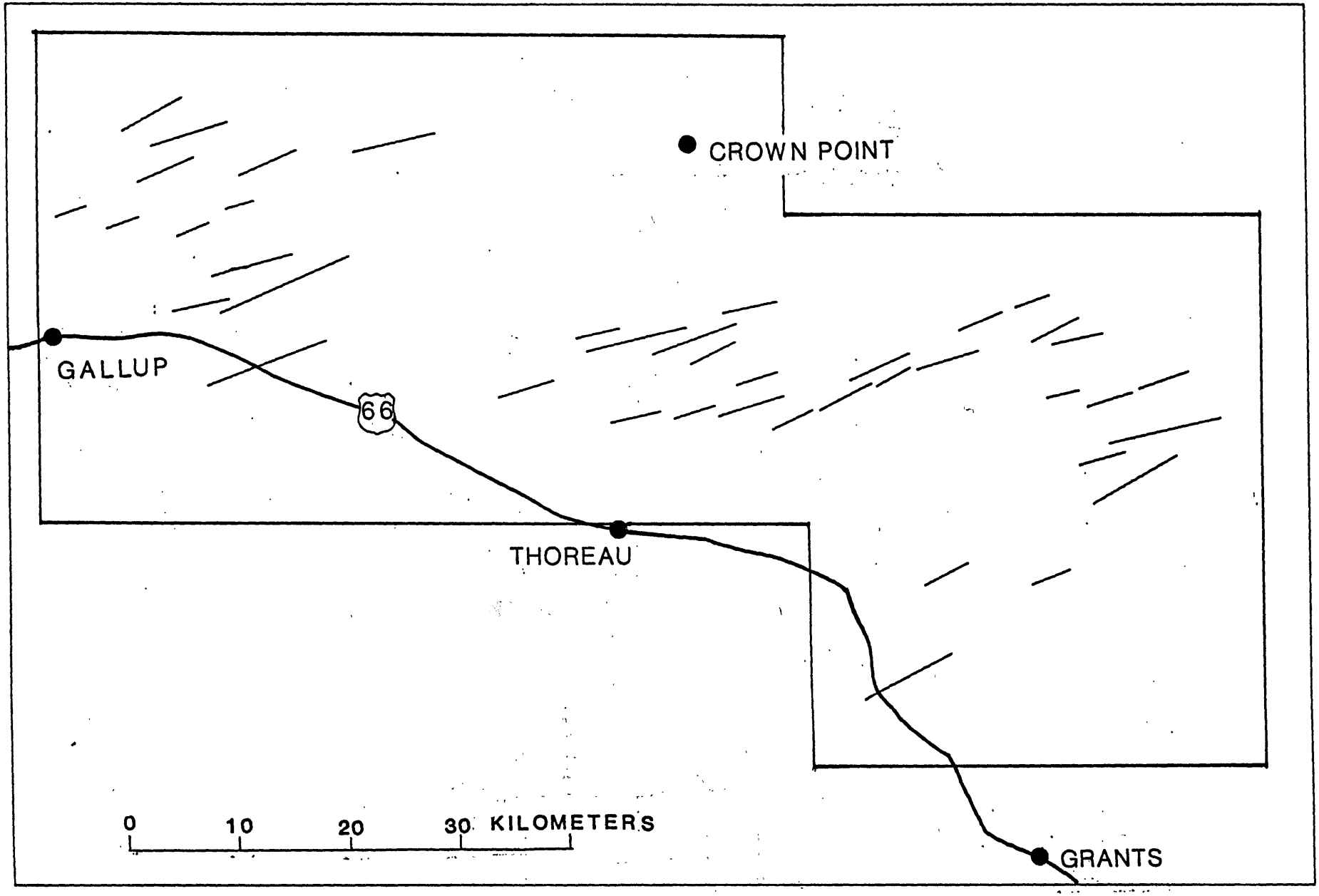

Figure 7.-Linear features of the Gallup-Grants uranium district, N. M..Trend interval is 60° to 80°

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Appendix A

Computer Printout

Computer Printout Length Frequency Analysis

Gallup-Grants Lengths

02/07/79 0959

START LINE 1; START PIXEL 1; NO. LINES 18; NO. PIXEL 10
LINE SKIP 0; PIXEL SKIP 0

MIN GRAY LEVEL 0; MAX GRAY LEVEL 300; MEAN GRAY LEVEL 84.1
MODE: GRAY LEVEL 72 OCCURS 6. TIMES
TOTAL PIXELS TESTED 180.
LOW PIXELS 0; HIGH PIXELS 1
PIXELS USED IN HISTOGRAM 179.

VARIANCE 1639.026 STANDARD DEVIATION 40.485

FREQUENCY HISTOGRAM-NORMALIZED TO 50

Length (km)	GRAYL	FREQ	CUM%	0 20 40 60 80 100
				+ + + + + +
	0	0.	0.0	+ + + + + +
	1	0.	0.0	+ + + + + +
	2	0.	0.0	+ + + + + +
	3	0.	0.0	+ + + + + +
	4	0.	0.0	+ + + + + +
	5	0.	0.0	+ + + + + +
	6	0.	0.0	+ + + + + +
	7	0.	0.0	+ + + + + +
	8	0.	0.0	+ + + + + +
	9	0.	0.0	+ + + + + +
	10	0.	0.0	+ + + + + +
	11	0.	0.0	+ + + + + +
	12	0.	0.0	+ + + + + +
	13	0.	0.0	+ + + + + +
	14	0.	0.0	+ + + + + +
	15	0.	0.0	+ + + + + +
1	16	0.	0.0	+ + + + + +
	17	0.	0.0	+ + + + + +
	18	0.	0.0	+ + + + + +
	19	0.	0.0	+ + + + + +
	20	0.	0.0	+ + + + + +
	21	0.	0.0	+ + + + + +
	22	0.	0.0	+ + + + + +
	23	0.	0.0	+ + + + + +
	24	0.	0.0	+ + + + + +
	25	0.	0.0	+ + + + + +
	26	0.	0.0	+ + + + + +
	27	0.	0.0	+ + + + + +
	28	0.	0.0	+ + + + + +
	29	0.	0.0	+ + + + + +
	30	0.	0.0	+ + + + + +
	31	0.	0.0	+ + + + + +
2	32	0.	0.0	+ + + + + +
	33	0.	0.0	+ + + + + +
	34	1.	0.6	********* + + + + +
	35	0.	0.6	+ + + + + +
	36	2.	1.7	****************** + + + +

1 grayl = 62.5 meters

```
    37      1.    2.2*********  +         +         +         +         +
    38      1.    2.8*********  +         +         +         +         +
    39      0.    2.8+          +         +         +         +         +
    40      1.    3.4*********  +         +         +         +         +
    41      1.    3.9*********  +         +         +         +         +
    42      1.    4.5*********  +         +         +         +         +
    43      3.    6.1**************************    +         +         +
    44      4.    8.4***********************************    +         +
    45      3.   10.1**************************    +         +         +
    46      1.   10.6*********  +         +         +         +         +
    47      1.   11.2*********  +         +         +         +         +
 3  48      2.   12.3*****************    +         +         +         +
    49      3.   14.0**************************    +         +         +
    50      2.   15.1*****************    +         +         +         +
    51      2.   16.2*****************    +         +         +         +
    52      5.   19.0************************************************    +
    53      2.   20.1*****************    +         +         +         +
    54      4.   22.3***********************************    +         +
    55      3.   24.0**************************    +         +         +
    56      3.   25.7**************************    +         +         +
    57      1.   26.3*********  +         +         +         +         +
    58      2.   27.4*****************    +         +         +         +
    59      1.   27.9*********  +         +         +         +         +
    60      1.   28.5*********  +         +         +         +         +
    61      3.   30.2**************************    +         +         +
    62      3.   31.8**************************    +         +         +
    63      5.   34.6************************************************    +
 4  64      2.   35.8*****************    +         +         +         +
    65      2.   36.9*****************    +         +         +         +
    66      4.   39.1***********************************    +         +
    67      1.   39.7*********  +         +         +         +         +
    68      4.   41.9***********************************    +         +
    69      2.   43.0*****************    +         +         +         +
    70      5.   45.8************************************************    +
    71      1.   46.4*********  +         +         +         +         +
    72      6.   49.7************************************************************
    73      0.   49.7+         +         +         +         +         +
    74      3.   51.4**************************    +         +         +
    75      4.   53.6***********************************    +         +
    76      2.   54.7*****************    +         +         +         +
    77      1.   55.3*********  +         +         +         +         +
    78      0.   55.3+         +         +         +         +         +
    79      2.   56.4*****************    +         +         +         +
 5  80      2.   57.5*****************    +         +         +         +
    81      3.   59.2**************************    +         +         +
    82      2.   60.3*****************    +         +         +         +
    83      4.   62.6***********************************    +         +
    84      1.   63.1*********  +         +         +         +         +
    85      0.   63.1+         +         +         +         +         +
    86      2.   64.2*****************    +         +         +         +
    87      1.   64.8*********  +         +         +         +         +
    88      1.   65.4*********  +         +         +         +         +
    89      4.   67.6***********************************    +         +
    90      3.   69.3**************************    +         +         +
    91      0.   69.3+         +         +         +         +         +
    92      1.   69.8*********  +         +         +         +         +
    93      0.   69.8+         +         +         +         +         +
    94      4.   72.1***********************************    +         +
    95      3.   73.7**************************    +         +         +
 6  96      2.   74.9*****************    +         +         +         +
```

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	104	1.	79.3*********	+	+	+	+	+
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	110	2.	83.8**********	+	+	+	+	+
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	207	0.	98.3+	+	+	+	+	+
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	213	0.	98.3+	+	+	+	+	+
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	215	0.	98.3+	+	+	+	+	+
	216	0.	98.3+	+	+	+	+	+

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	223	0.	98.3+
14	224	0.	98.3+
	225	0.	98.3+
	226	0.	98.3+
	227	0.	98.3+
	228	0.	98.3+
	229	0.	98.3+
	230	0.	98.3+
	231	0.	98.3+
	232	1.	98.9*********
	233	0.	98.9+
	234	0.	98.9+
	235	0.	98.9+
	236	0.	98.9+
	237	0.	98.9+
	238	0.	98.9+
	239	0.	98.9+
15	240	0.	98.9+
	241	0.	98.9+
	242	0.	98.9+
	243	0.	98.9+
	244	0.	98.9+
	245	0.	98.9+
	246	0.	98.9+
	247	0.	98.9+
	248	0.	98.9+
	249	0.	98.9+
	250	0.	98.9+
	251	0.	98.9+
	252	0.	98.9+
	253	0.	98.9+
	254	0.	98.9+
	255	0.	98.9+
16	256	0.	98.9+
	257	0.	98.9+
	258	0.	98.9+
	259	0.	98.9+
	260	0.	98.9+
	261	0.	98.9+
	262	0.	98.9+
	263	0.	98.9+
	264	0.	98.9+
	265	0.	98.9+
	266	1.	99.4*********
	267	0.	99.4+
	268	0.	99.4+
	269	0.	99.4+
	270	0.	99.4+
	271	0.	99.4+
17	272	0.	99.4+
	273	0.	99.4+
	274	0.	99.4+
	275	0.	99.4+
	276	1.	100.0*********

Appendix B

Computer Printout

Unweighted Strike-Frequency Analysis

ABSOLUTE STRIKE FREQUENCY ANALYSIS.

Unweighted Gallup-Grants

10 LEVELS OF FREQUENCY AT 1 PER LEVEL.

NO. OF DATA = 187

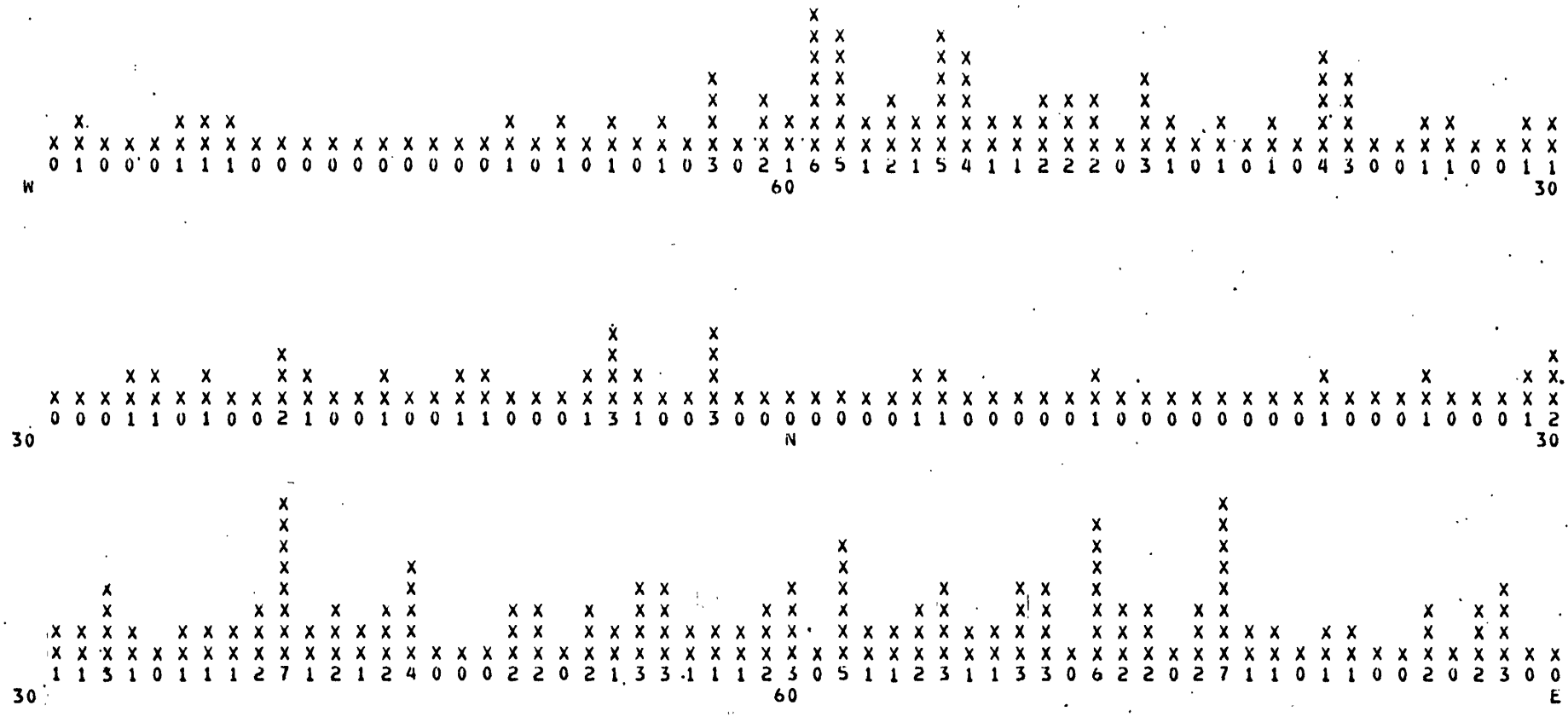


TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ
271	-89	0	316	-44	0	1	1	0	46	46	0
272	-88	1	317	-43	1	2	2	0	47	47	0
273	-87	0	318	-42	0	3	3	0	48	48	0
274	-86	0	319	-41	1	4	4	0	49	49	2
275	-85	0	320	-40	0	5	5	1	50	50	2
276	-84	1	321	-39	4	6	6	1	51	51	0
277	-83	1	322	-38	3	7	7	0	52	52	2
278	-82	1	323	-37	0	8	8	0	53	53	1
279	-81	0	324	-36	0	9	9	0	54	54	3
280	-80	0	325	-35	1	10	10	0	55	55	3
281	-79	0	326	-34	1	11	11	0	56	56	1
282	-78	0	327	-33	0	12	12	1	57	57	1
283	-77	0	328	-32	0	13	13	0	58	58	1
284	-76	0	329	-31	1	14	14	0	59	59	2
285	-75	0	330	-30	1	15	15	0	60	60	3
286	-74	0	331	-29	0	16	16	0	61	61	0
287	-73	0	332	-28	0	17	17	0	62	62	5
288	-72	0	333	-27	0	18	18	0	63	63	1
289	-71	1	334	-26	1	19	19	0	64	64	1
290	-70	0	335	-25	1	20	20	0	65	65	2
291	-69	1	336	-24	0	21	21	1	66	66	3
292	-68	0	337	-23	1	22	22	0	67	67	1
293	-67	1	338	-22	0	23	23	0	68	68	1
294	-66	0	339	-21	0	24	24	0	69	69	3
295	-65	1	340	-20	2	25	25	1	70	70	3
296	-64	0	341	-19	1	26	26	0	71	71	0
297	-63	3	342	-18	0	27	27	0	72	72	6
298	-62	0	343	-17	0	28	28	0	73	73	2
299	-61	2	344	-16	1	29	29	1	74	74	2
300	-60	1	345	-15	0	30	30	2	75	75	0
301	-59	6	346	-14	0	31	31	1	76	76	2
302	-58	5	347	-13	1	32	32	1	77	77	7
303	-57	1	348	-12	1	33	33	3	78	78	1
304	-56	2	349	-11	0	34	34	1	79	79	1
305	-55	1	350	-10	0	35	35	0	80	80	0
306	-54	5	351	-9	0	36	36	1	81	81	1
307	-53	4	352	-8	1	37	37	1	82	82	1
308	-52	1	353	-7	3	38	38	1	83	83	0
309	-51	1	354	-6	1	39	39	2	84	84	0
310	-50	2	355	-5	0	40	40	7	85	85	2
311	-49	2	356	-4	0	41	41	1	86	86	0
312	-48	2	357	-3	3	42	42	2	87	87	2
313	-47	0	358	-2	0	43	43	1	88	88	3
314	-46	3	359	-1	0	44	44	2	89	89	0
315	-45	1	360	0	0	45	45	4	90	90	0

EMPIRICAL STRIKE FREQUENCY ANALYSIS.

Unweighted Gallup-Grants

10 LEVELS OF FREQUENCY AT 2 PER LEVEL.

PERCENT AZIMUTH FOR SMOOTHING = 2.78

NO. OF DATA = 187

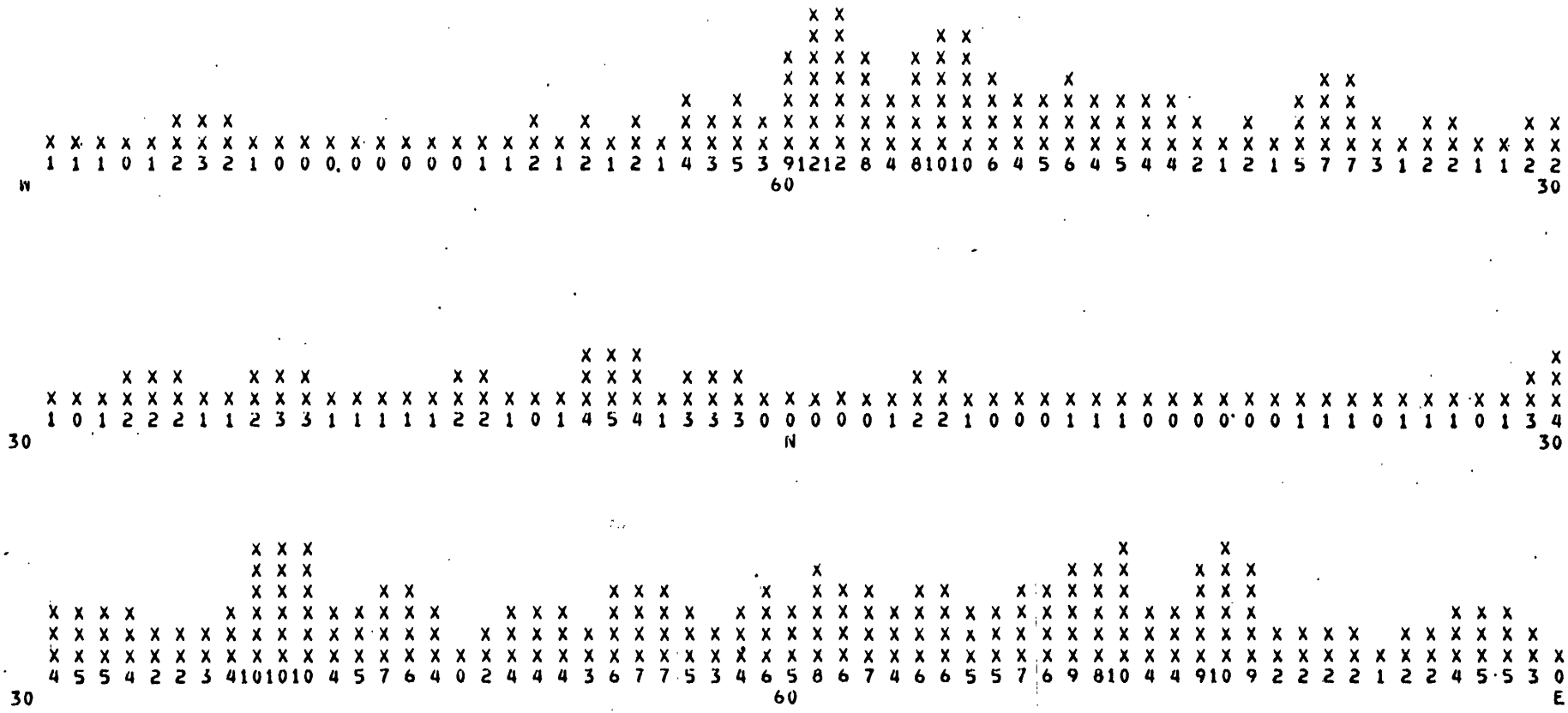


TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ
271	-89	1	316	-44	2	1	1	0	46	46	4
272	-88	1	317	-43	1	2	2	0	47	47	0
273	-87	1	318	-42	2	3	3	0	48	48	2
274	-86	0	319	-41	1	4	4	1	49	49	4
275	-85	1	320	-40	5	5	5	2	50	50	4
276	-84	2	321	-39	7	6	6	2	51	51	4
277	-83	3	322	-38	7	7	7	1	52	52	3
278	-82	2	323	-37	3	8	8	0	53	53	6
279	-81	1	324	-36	1	9	9	0	54	54	7
280	-80	0	325	-35	2	10	10	0	55	55	7
281	-79	0	326	-34	2	11	11	1	56	56	5
282	-78	0	327	-33	1	12	12	1	57	57	3
283	-77	0	328	-32	1	13	13	1	58	58	4
284	-76	0	329	-31	2	14	14	0	59	59	6
285	-75	0	330	-30	2	15	15	0	60	60	5
286	-74	0	331	-29	1	16	16	0	61	61	8
287	-73	0	332	-28	0	17	17	0	62	62	6
288	-72	1	333	-27	1	18	18	0	63	63	7
289	-71	1	334	-26	2	19	19	0	64	64	4
290	-70	2	335	-25	2	20	20	1	65	65	6
291	-69	1	336	-24	2	21	21	1	66	66	6
292	-68	2	337	-23	1	22	22	1	67	67	5
293	-67	1	338	-22	1	23	23	0	68	68	5
294	-66	2	339	-21	2	24	24	1	69	69	7
295	-65	1	340	-20	3	25	25	1	70	70	6
296	-64	4	341	-19	3	26	26	1	71	71	9
297	-63	3	342	-18	1	27	27	0	72	72	8
298	-62	5	343	-17	1	28	28	1	73	73	10
299	-61	3	344	-16	1	29	29	3	74	74	4
300	-60	9	345	-15	1	30	30	4	75	75	4
301	-59	12	346	-14	1	31	31	4	76	76	9
302	-58	12	347	-13	2	32	32	5	77	77	10
303	-57	8	348	-12	2	33	33	5	78	78	9
304	-56	4	349	-11	1	34	34	4	79	79	2
305	-55	8	350	-10	0	35	35	2	80	80	2
306	-54	10	351	-9	1	36	36	2	81	81	2
307	-53	10	352	-8	4	37	37	3	82	82	2
308	-52	6	353	-7	5	38	38	4	83	83	1
309	-51	4	354	-6	4	39	39	10	84	84	2
310	-50	5	355	-5	1	40	40	10	85	85	2
311	-49	6	356	-4	3	41	41	10	86	86	4
312	-48	4	357	-3	3	42	42	4	87	87	5
313	-47	5	358	-2	3	43	43	5	88	88	5
314	-46	4	359	-1	0	44	44	7	89	89	3
315	-45	4	360	0	0	45	45	6	90	90	0

Unweighted Gallup-Grants

FREQUENCY PROBABILITY DATA

NO. OF DATA = 187 EVENT PROB. = 0.028 PROB. LIMIT = 0.970

FREQUENCY MEAN = 5.2

EMP. FREQ.	REL. FREQ.	FREQ. PROB.	SIGNIF VALUE	SIGNIFICANCE 0 .2 .4 .6 .8 1.0
1	1.0	0.029	94.1	X
2	1.6	0.075	81.2	X
3	2.1	0.130	59.0	X
4	2.6	0.168	30.0	X
5	3.2	0.175	0.0	
6	3.7	0.151	0.0	
7	4.2	0.112	36.2	X
8	4.8	0.073	63.1	X
9	5.3	0.042	80.5	X
10	5.8	0.022	90.6	X

LOCATION OF MAXIMA AND THEIR SIGNIFICANCE VALUES.

AZIMUTH	EMP. FREQ.	SIG. VALUE
301	12	99.9
306	10	90.6
311	6	0.0
321	7	36.2
40	10	90.6
44	7	36.2
54	7	36.2
59	6	0.0
61	8	63.1
63	7	36.2
66	6	0.0
69	7	36.2
71	9	80.5
73	10	90.6
77	10	90.6

Appendix C

Computer Printout

Length-Weighted Strike-Frequency Analysis

ABSOLUTE STRIKE FREQUENCY ANALYSIS.

Length-Weighted Gallup-Grants

10 LEVELS OF FREQUENCY AT 70 PER LEVEL.

NO. OF DATA = 16048

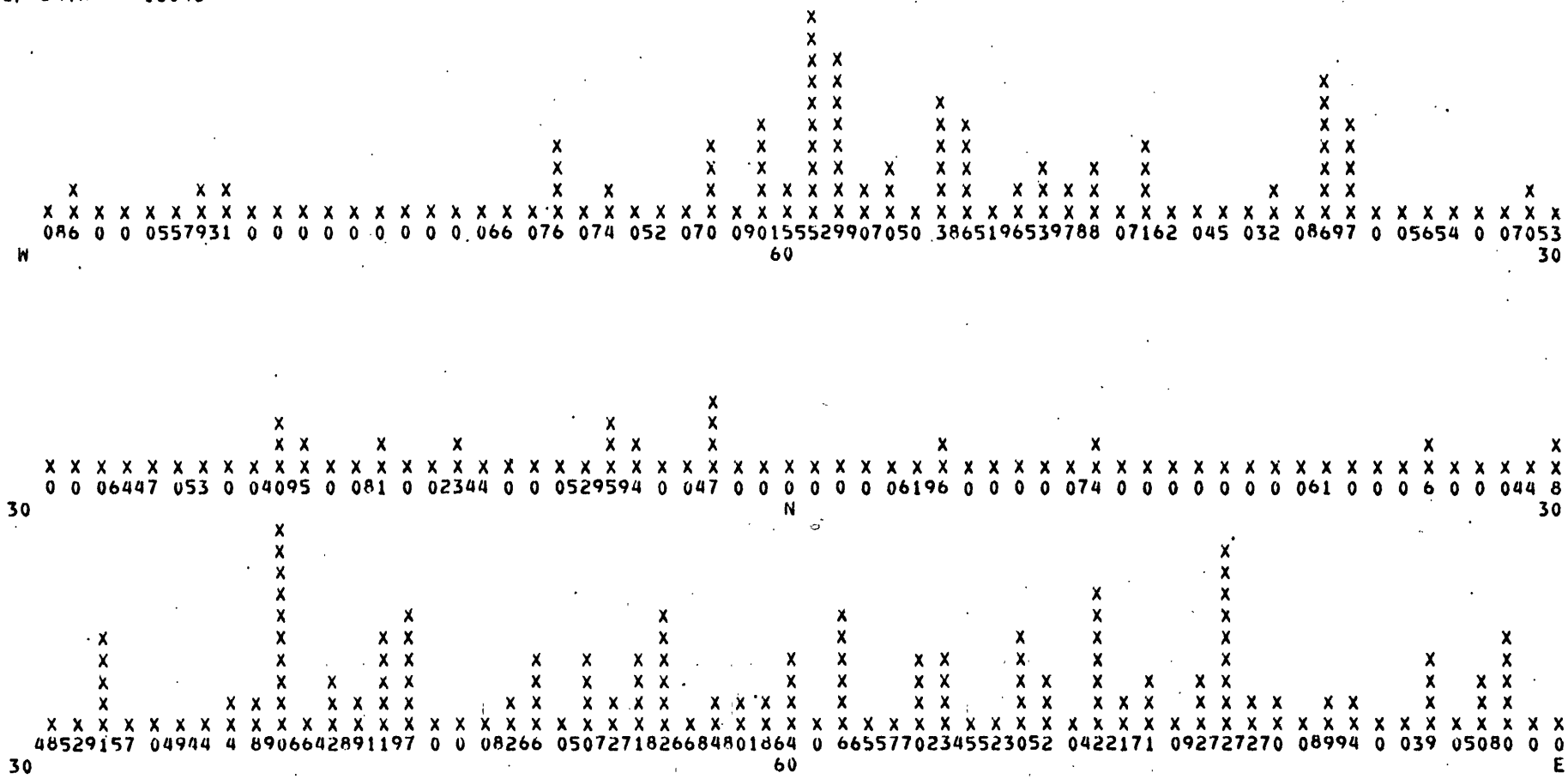


TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ
271	-89	0	316	-44	0	1	1	0	46	46	0
272	-88	86	317	-43	45	2	2	0	47	47	0
273	-87	0	318	-42	0	3	3	0	48	48	0
274	-86	0	319	-41	132	4	4	0	49	49	82
275	-85	0	320	-40	0	5	5	61	50	50	266
276	-84	55	321	-39	486	6	6	96	51	51	0
277	-83	79	322	-38	297	7	7	0	52	52	250
278	-82	131	323	-37	0	8	8	0	53	53	72
279	-81	0	324	-36	0	9	9	0	54	54	271
280	-80	0	325	-35	56	10	10	0	55	55	382
281	-79	0	326	-34	54	11	11	0	56	56	66
282	-78	0	327	-33	0	12	12	74	57	57	84
283	-77	0	328	-32	0	13	13	0	58	58	80
284	-76	0	329	-31	70	14	14	0	59	59	118
285	-75	0	330	-30	53	15	15	0	60	60	264
286	-74	0	331	-29	0	16	16	0	61	61	0
287	-73	0	332	-28	0	17	17	0	62	62	406
288	-72	0	333	-27	0	18	18	0	63	63	65
289	-71	66	334	-26	64	19	19	0	64	64	57
290	-70	0	335	-25	47	20	20	0	65	65	270
291	-69	276	336	-24	0	21	21	61	66	66	223
292	-68	0	337	-23	53	22	22	0	67	67	45
293	-67	74	338	-22	0	23	23	0	68	68	52
294	-66	0	339	-21	0	24	24	0	69	69	330
295	-65	52	340	-20	140	25	25	106	70	70	152
296	-64	0	341	-19	95	26	26	0	71	71	0
297	-63	270	342	-18	0	27	27	0	72	72	442
298	-62	0	343	-17	0	28	28	0	73	73	121
299	-61	290	344	-16	81	29	29	44	74	74	171
300	-60	115	345	-15	0	30	30	108	75	75	0
301	-59	655	346	-14	0	31	31	48	76	76	192
302	-58	529	347	-13	123	32	32	52	77	77	572
303	-57	90	348	-12	44	33	33	291	78	78	72
304	-56	170	349	-11	0	34	34	57	79	79	70
305	-55	50	350	-10	0	35	35	0	80	80	0
306	-54	403	351	-9	0	36	36	49	81	81	89
307	-53	286	352	-8	52	37	37	44	82	82	94
308	-52	51	353	-7	195	38	38	104	83	83	0
309	-51	96	354	-6	94	39	39	108	84	84	0
310	-50	153	355	-5	0	40	40	690	85	85	239
311	-49	97	356	-4	0	41	41	66	86	86	0
312	-48	188	357	-3	247	42	42	142	87	87	150
313	-47	0	358	-2	0	43	43	89	88	88	280
314	-46	271	359	-1	0	44	44	311	89	89	0
315	-45	62	360	0	0	45	45	397	90	90	0

EMPIRICAL STRIKE FREQUENCY ANALYSIS.

Length-weighted Gallup-Grants

10 LEVELS OF FREQUENCY AT 130 PER LEVEL.

PERCENT AZIMUTH FOR SMOOTHING = 1.67

NO. OF DATA = 16048

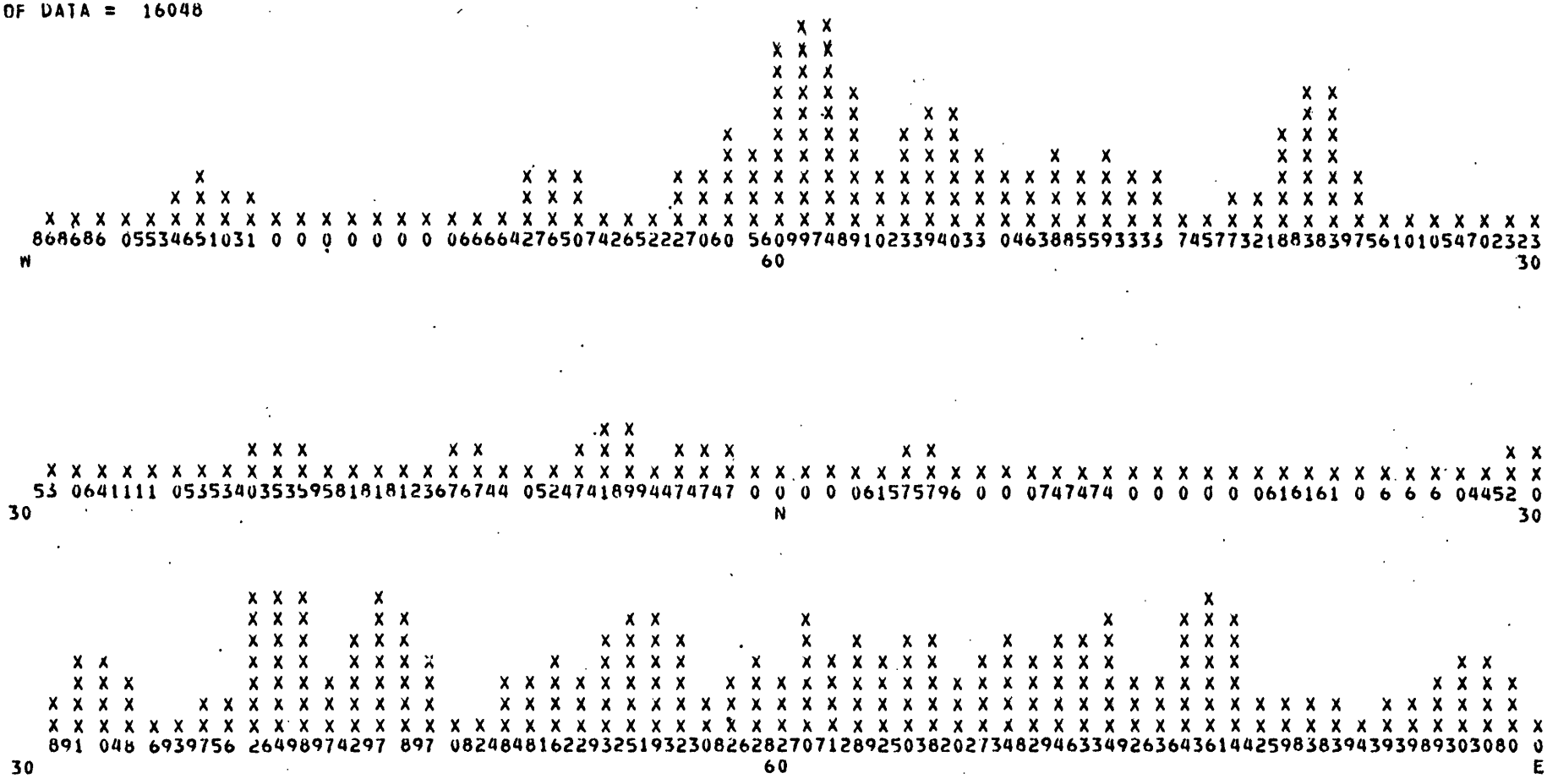


TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

AZIM	BRNG	FREQ
271	-89	86
272	-88	86
273	-87	86
274	-86	0
275	-85	55
276	-84	134
277	-83	265
278	-82	210
279	-81	131
280	-80	0
281	-79	0
282	-78	0
283	-77	0
284	-76	0
285	-75	0
286	-74	0
287	-73	0
288	-72	66
289	-71	66
290	-70	342
291	-69	276
292	-68	350
293	-67	74
294	-66	126
295	-65	52
296	-64	322
297	-63	270
298	-62	560
299	-61	405
300	-60	1060
301	-59	1299
302	-58	1274
303	-57	789
304	-56	310
305	-55	623
306	-54	739
307	-53	740
308	-52	433
309	-51	300
310	-50	346
311	-49	438
312	-48	285
313	-47	459
314	-46	333
315	-45	333
316	-44	107
317	-43	45
318	-42	177
319	-41	132
320	-40	618
321	-39	783
322	-38	783
323	-37	297
324	-36	56
325	-35	110
326	-34	110
327	-33	54
328	-32	70
329	-31	123
330	-30	123
331	-29	53
332	-28	0
333	-27	64
334	-26	111
335	-25	111
336	-24	100
337	-23	53
338	-22	53
339	-21	140
340	-20	235
341	-19	235
342	-18	95
343	-17	81
344	-16	81
345	-15	81
346	-14	123
347	-13	167
348	-12	167
349	-11	44
350	-10	0
351	-9	52
352	-8	247
353	-7	341
354	-6	289
355	-5	94
356	-4	247
357	-3	247
358	-2	247
359	-1	0
360	0	0
1	1	0
2	2	0
3	3	0
4	4	61
5	5	157
6	6	157
7	7	96
8	8	0
9	9	0
10	10	0
11	11	74
12	12	74
13	13	74
14	14	0
15	15	0
16	16	0
17	17	0
18	18	0
19	19	0
20	20	61
21	21	61
22	22	61
23	23	0
24	24	106
25	25	106
26	26	106
27	27	0
28	28	44
29	29	152
30	30	200
31	31	208
32	32	391
33	33	400
34	34	348
35	35	106
36	36	93
37	37	197
38	38	256
39	39	902
40	40	864
41	41	898
42	42	297
43	43	542
44	44	797
45	45	708
46	46	397
47	47	0
48	48	82
49	49	348
50	50	348
51	51	516
52	52	322
53	53	593
54	54	725
55	55	719
56	56	532
57	57	230
58	58	282
59	59	462
60	60	382
61	61	670
62	62	471
63	63	528
64	64	392
65	65	550
66	66	538
67	67	320
68	68	427
69	69	534
70	70	482
71	71	594
72	72	563
73	73	734
74	74	292
75	75	363
76	76	764
77	77	836
78	78	714
79	79	142
80	80	159
81	81	183
82	82	183
83	83	94
84	84	239
85	85	239
86	86	389
87	87	430
88	88	430
89	89	280
90	90	0

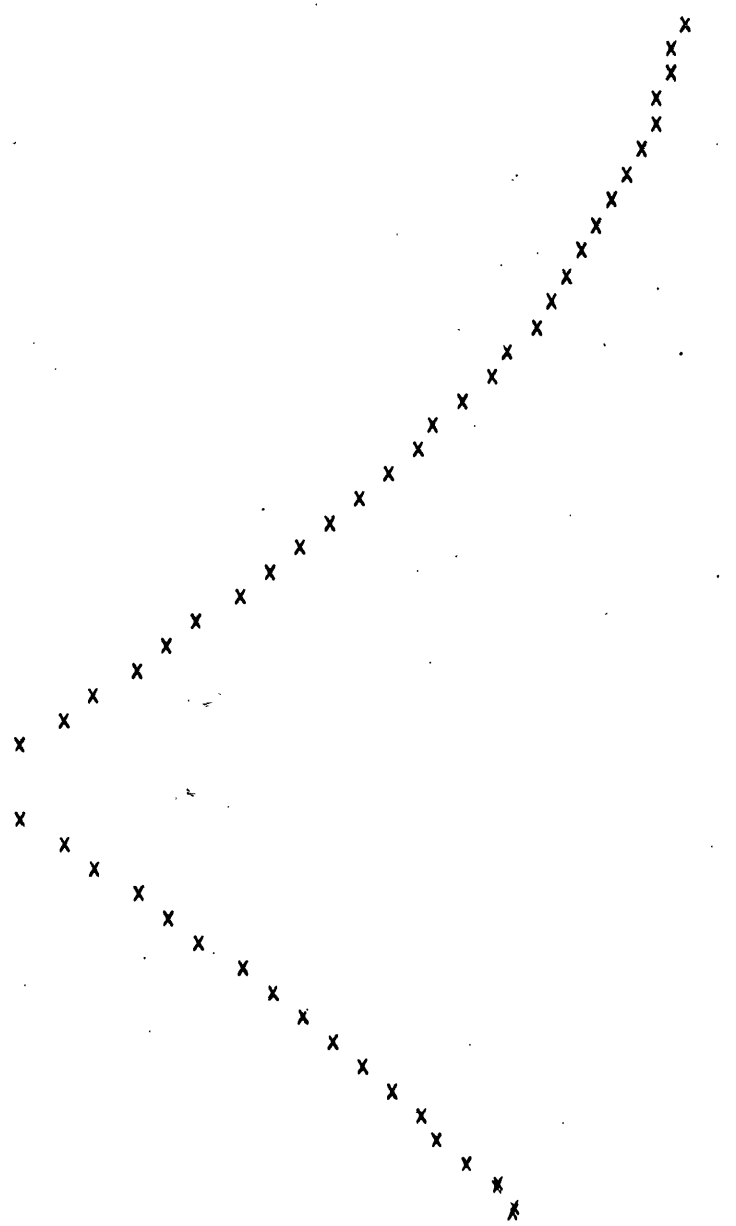
Length-Weighted Gallup-Grants

FREQUENCY PROBABILITY DATA

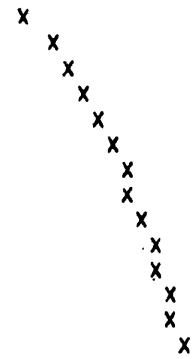
NO. OF DATA = 16048 EVENT PROB. = 0.017 PROB. LIMIT = 0.970

FREQUENCY MEAN = 267.5

EMP. FREQ.	RFL. FREQ.	FREQ. PROB.	SIGNIF VALUE
237	2.0	0.004	93.7
238	2.0	0.005	92.8
239	2.0	0.005	91.7
240	2.0	0.006	90.5
241	2.0	0.007	89.2
242	2.0	0.007	87.8
243	2.0	0.008	86.2
244	2.0	0.009	84.4
245	2.0	0.010	82.5
246	2.0	0.010	80.5
247	2.0	0.011	78.2
248	2.0	0.012	75.8
249	2.1	0.013	73.2
250	2.1	0.014	70.4
251	2.1	0.015	67.4
252	2.1	0.016	64.3
253	2.1	0.017	60.9
254	2.1	0.018	57.4
255	2.1	0.019	53.7
256	2.1	0.019	49.9
257	2.1	0.020	45.9
258	2.1	0.021	41.7
259	2.1	0.022	37.4
260	2.1	0.022	33.0
261	2.1	0.023	28.5
262	2.1	0.023	23.9
263	2.1	0.024	19.2
264	2.1	0.024	14.5
265	2.2	0.024	9.7
266	2.2	0.024	4.8
267	2.2	0.024	0.0
268	2.2	0.024	-0.0
269	2.2	0.024	4.9
270	2.2	0.024	9.8
271	2.2	0.024	14.7
272	2.2	0.023	19.4
273	2.2	0.023	24.1
274	2.2	0.022	28.7
275	2.2	0.022	33.2
276	2.2	0.021	37.6
277	2.2	0.020	41.8
278	2.2	0.019	45.9
279	2.2	0.019	49.9
280	2.2	0.018	53.6
281	2.3	0.017	57.3
282	2.3	0.016	60.7
283	2.3	0.015	63.9
284	2.3	0.014	67.0
285	2.3	0.013	69.9



286	2.3	0.013	72.6
287	2.3	0.012	75.2
288	2.3	0.011	77.5
289	2.3	0.010	79.7
290	2.3	0.009	81.8
291	2.3	0.009	83.7
292	2.3	0.008	85.4
293	2.3	0.007	87.0
294	2.3	0.007	88.4
295	2.3	0.006	89.7
296	2.3	0.005	90.9
297	2.4	0.005	92.0
298	2.4	0.004	93.0
299	2.4	0.004	93.8



LOCATION OF MAXIMA AND THEIR SIGNIFICANCE VALUES.

AZIMUTH	EMP. FREQ.	SIG. VALUE
290	342	99.9
292	350	99.9
296	322	99.9
298	560	99.9
301	1299	99.9
307	740	99.9
311	438	99.9
313	459	99.9
321	783	99.9
353	341	99.9
33	400	99.9
39	902	99.9
41	898	99.9
44	797	99.9
51	516	99.9
54	725	99.9
59	462	99.9
61	670	99.9
63	528	99.9
65	550	99.9
69	534	99.9
71	594	99.9
73	734	99.9
77	836	99.9
87	430	99.9