Maps of Linear Features and a Preliminary Lineament Interpretation of Western, South Dakota

by

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Open-File Report 79-595

1979

Illustrations

Discussion

This report presents a preliminary lineament analysis of a 25,000 sq. km. area in central western South Dakota and the data used in this analysis. The analysis presented is very preliminary at this time and requires much more work before any firm conclusions can be drawn. Plate 1 shows the location of the study area and the linear features mapped from enhanced Landsat images. The procedures and terminology used in this report and particularly with regard to the appendices are discussed in detail by Sawatzky and Raines (in press). The term linear feature is used to mean a rectilinear or curvilinear feature on an image or photograph that is selected and mapped by a skilled photogeologic interpreter (Sawatzky and Raines, in press). Lineament is used in this report to refer to an interpreted, linear geologic entity that is defined by linear concentrations of linear features. This is a new definition not used as yet by others. Therefore, the lines on Plate 1 are linear features, Plates 2 through 5 show selected examples of linear-feature concentration maps from which lineaments are interpreted, and the lines on Plate 6 are the lineaments that are defined from the analysis of Plates 2 through 5.

Plate 1 shows the linear features map produced from my analysis of Landsat scene E-1081-17065 (12 Oct 71). The digitized data for this Landsat scene were processed to enhance linear features, and the enhanced images were interpreted at a scale of 1:800,000. A total of 888 linear features were observed with a total ground length of 4164 km. These data were then statistically analyzed using the procedures

discussed in Sawatzky and Raines (in press). The statistics shown in Appendices 1 and 2 are summarized in figure 1. Six intervals are defined as being statistically significant at a 90 percent significant value (fig. 1). The subdivision of the northeast to east-west intervals into several intervals probably is not geologically significant. This conclusion is supported by the linear features concentration maps shown in Plates 2 through 5. These maps were produced by computer-contouring the spatial concentration of linear features in statistically defined directional intervals. The spatial concentration is the length of selected linear features per unit cell; the unit cell is 3.5 km on a side on the ground. From comparison of these maps, it is apparent that the various subdivisions of the northeast to east-west intervals are spatially related and form curving, long linear patterns; thus the northeast subdivisions are parts of one pattern.

From the analysis of Plates 1 through 5, the lineaments shown in Plate 6 are defined. The lineaments shown as solid lines seem to be well defined, and the lineaments shown as dashed lines are suggested but poorly defined by the data. When this map was completed I found that George Shurr had independently analyzed lineaments of the same area in South Dakota (Shurr, 1977). Shurr (oral commun., 1977) stated that this interpretation was in agreement with his interpretation of major lineaments in this part of South Dakoa.

The geologic significance of the northeast to east-west trending lineaments is discussed by Shurr (in press); he concludes that these lineaments are probably basement zones of instability that have

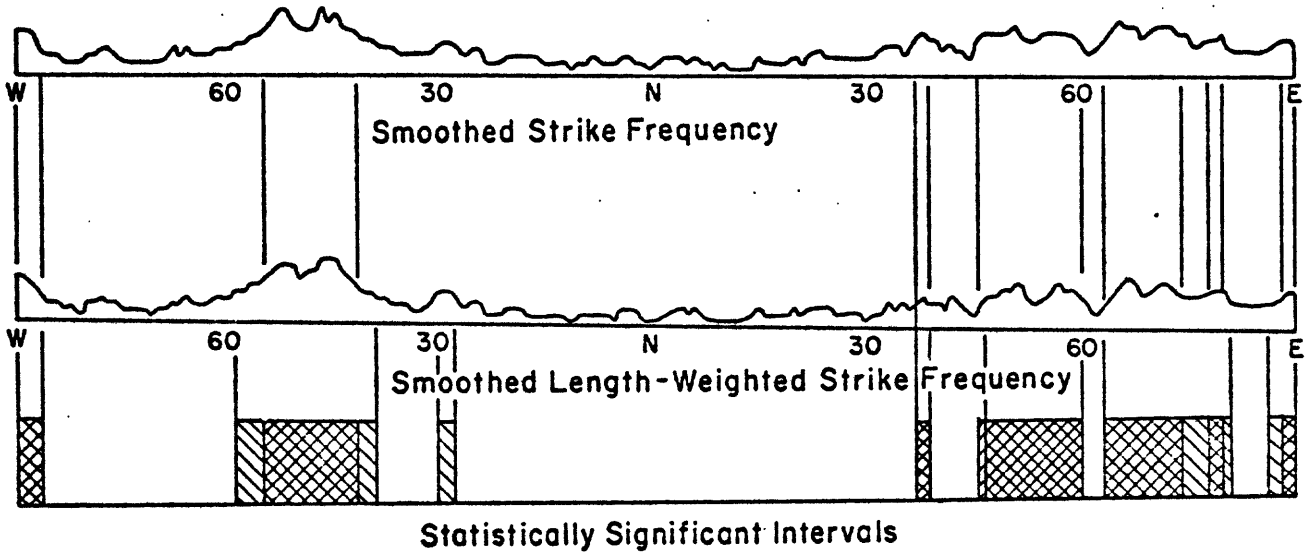

Figure 1.--Summary of directional analysis of linear features. Ruled lines that are up to the right denote the statistically significant intervals from the strike frequency analysis; those that are up to the left denote the statistically significant intervals from the length-weighted strike frequency analysis.

influenced the sea-floor topography in the Cretaceous seas and thus the environment of deposition and related facies deposited.

The northwest-trending lineaments are more poorly understood at this time. However, these lineaments may also be coincident with Cretaceous facies boundaries (Shurr, oral commun., 1977) or somehow related to the Black Hills structure.

I would like to acknowledge Richard F. Bretz, South Dakota Geological Survey, and George W. Shurr, U.S. Geological Survey, for much useful discussion and assistance in this work.

References

Sawatzky, D. L., and Raines, G. L., in press, Geologic uses of linear-features maps derived from small-scale images: Proceedings of Third Basement Tectonics Symposium, Durango, Colo., 1978.

Shurr, G. W., 1977, Landsat lineaments in western South Dakota: U.S. Geological Survey Opne-File Report 77-249.

Shurr, G. W., in press, Upper Cretaceous paleotectonic activity on lineaments in western South Dakota: Proceedings of Third Basement Tectonics Symposium, Durango, Colc., 1978.

Appendix 1: Strike Frequency Statistical Data

ABSOLUTE STRIKE FREQUENCY ANALYSIS.

S. Dakota lineaments

10 LEVELS OF FREQUENCY AT 2 PER LEVEL.

NO. OF DATA = 888

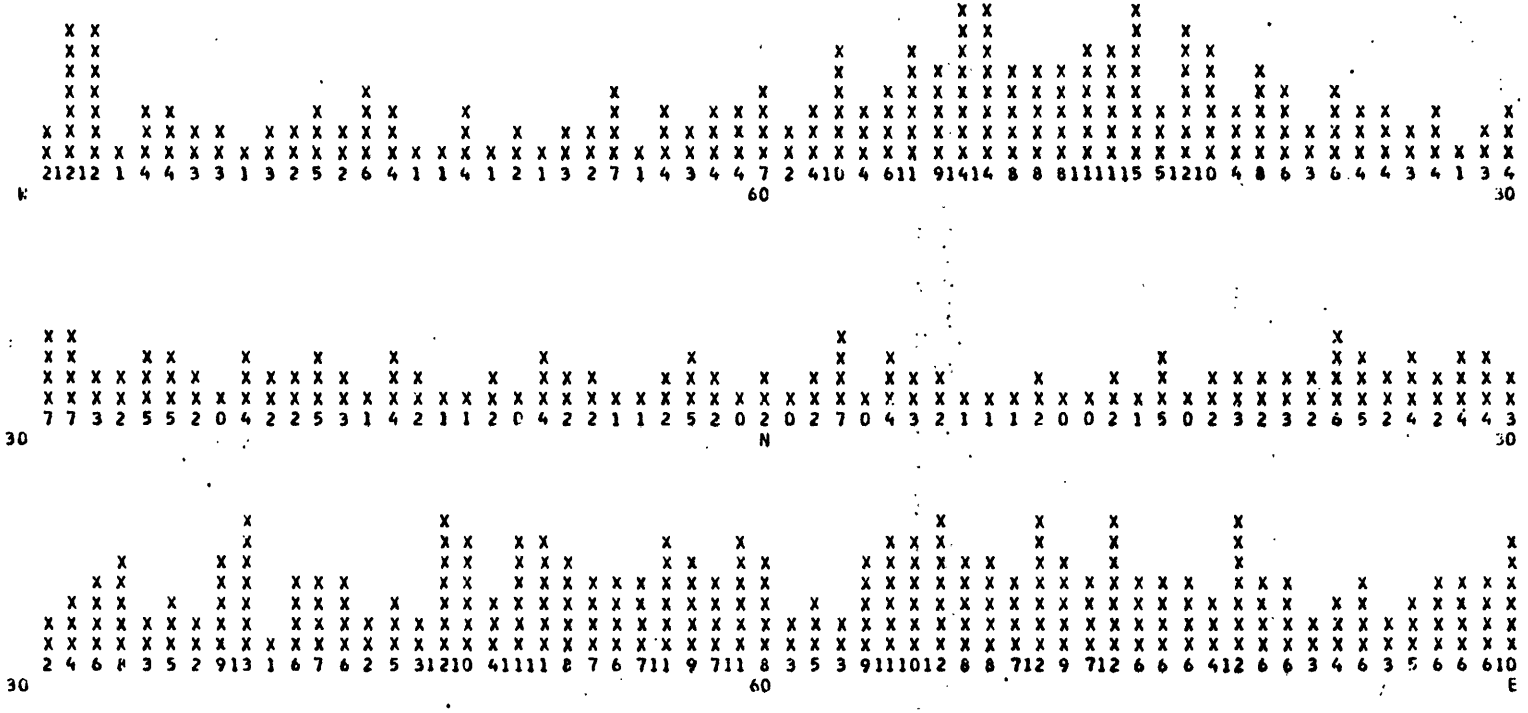

TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

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

EMPIRICAL STRIKE FREQUENCY ANALYSIS.

S. Dakota lineaments

10 LEVELS IF FREQUENCY AT 4 PER LEVEL.

PERCENT AZIMUTH FOR SMOOTHING = 1.67

NO. OF DATA = 888

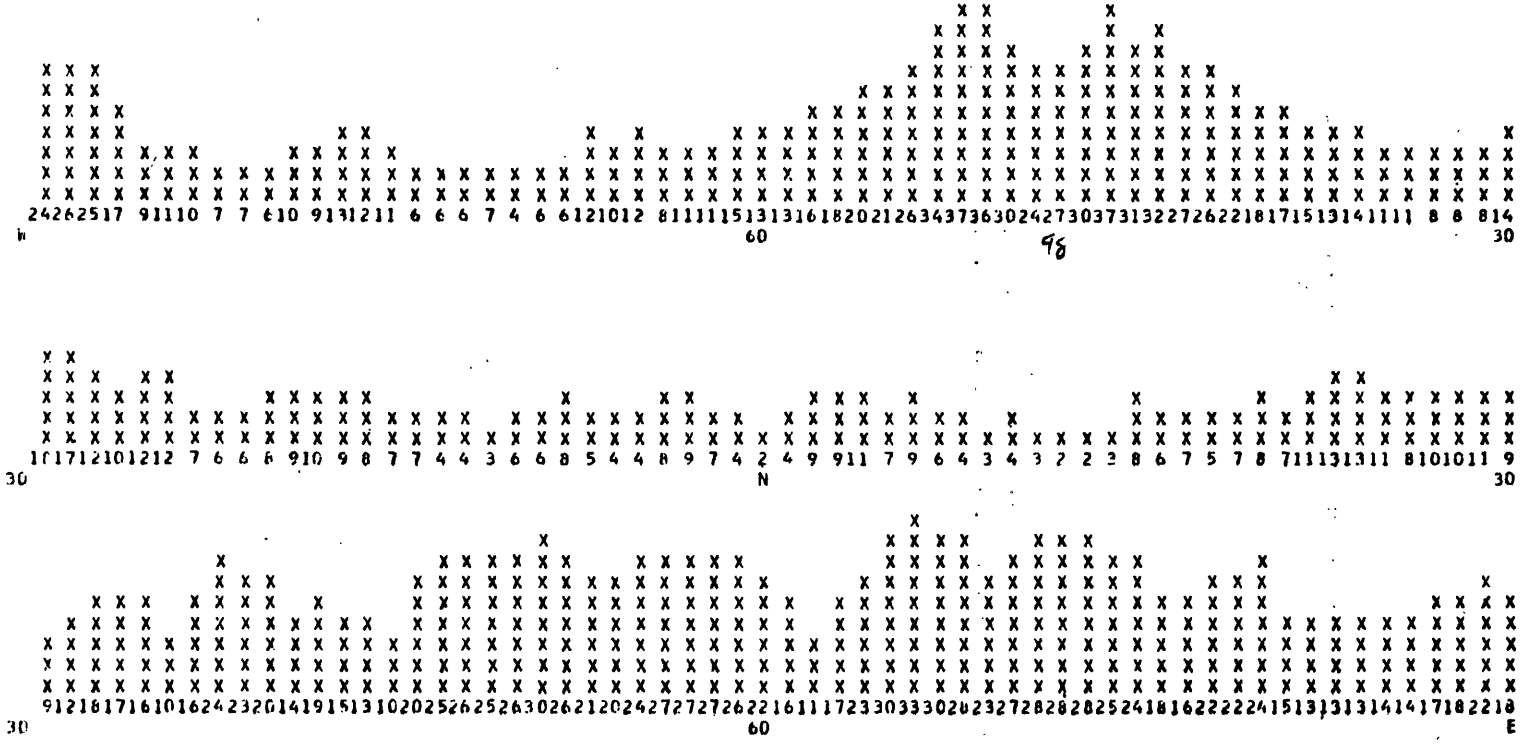

TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

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

271 - 273
306 - 319
38 - 39
47 - 52
55 - 60
64 - 75
78 - 80
89

S. Dakota lineaments

FREQUENCY PROBABILITY DATA

NO. OF DATA = 868 EVENT PROB. = 0.017 PROB. LIMIT = 0.950

FREQUENCY MEAN = 14.8

EMP. FREQ.	REL. FREQ.	FREQ. PROB.	SIGNIF VALUE	SIGNIFICANCE 0 .2 .4 .6 .8 1.0
9	1.5	0.035	34.2	
10	1.6	0.052	73.6	
11	1.7	0.070	59.2	
12	1.9	0.086	41.5	
13	2.0	0.098	21.3	
14	2.1	0.104	0.0	
15	2.2	0.102	-0.0	
16	2.3	0.095	19.9	
17	2.4	0.082	36.3	
18	2.5	0.068	54.4	
19	2.6	0.053	67.6	
20	2.8	0.039	77.8	
21	2.9	0.028	85.4	

Appendix 2: Length-weighted Strike Frequency Statistical Data

ABSOLUTE STRIKE FREQUENCY ANALYSIS.

S. Dakota lineaments length weighted

10 LEVELS OF FREQUENCY AT 46 PER LEVEL.

NO. OF DATA = 20490

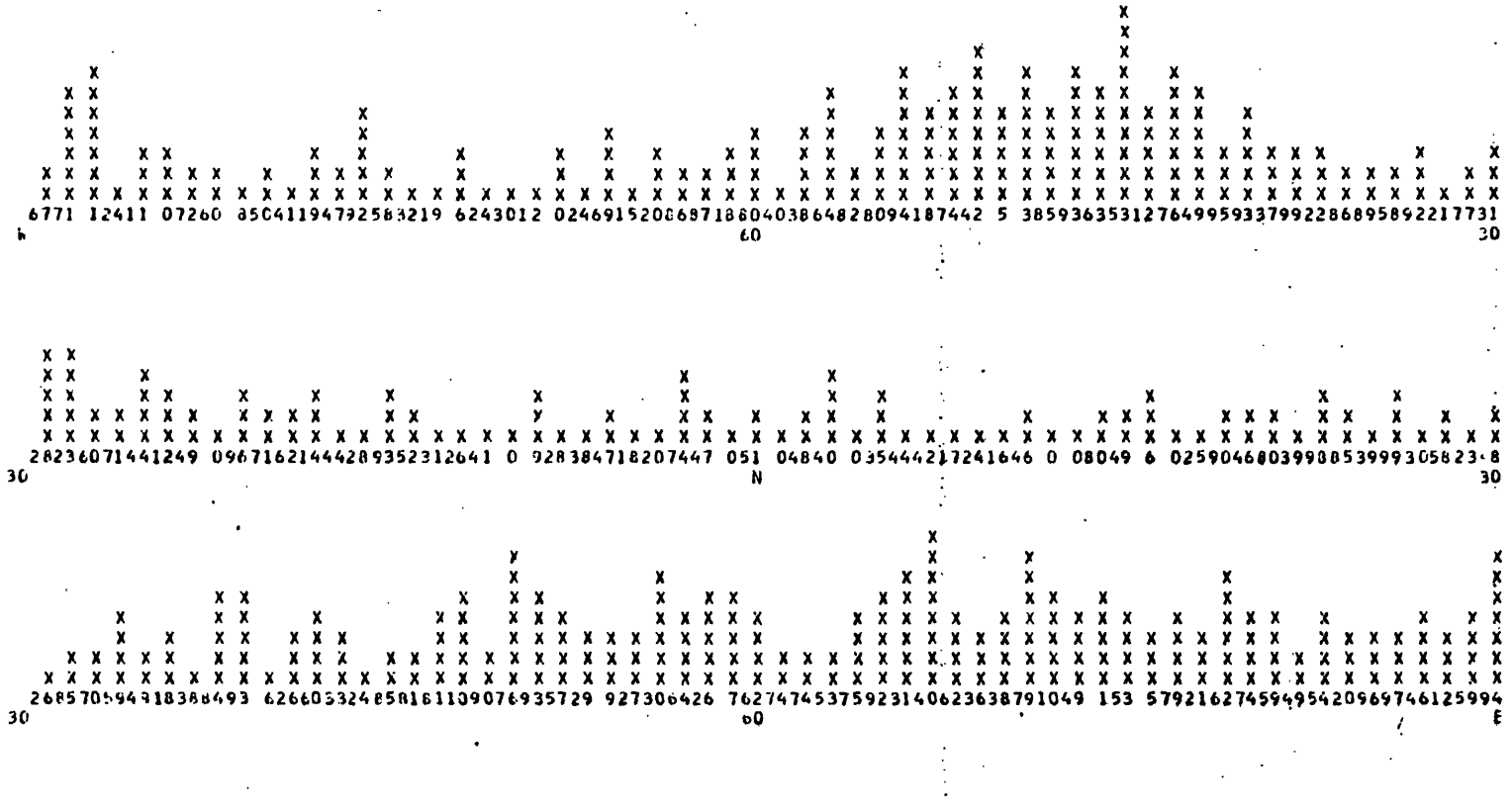

TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ
271	-89	67	316	-44	212	1	1	0	46	46	81
272	-88	271	317	-43	276	2	2	48	47	47	181
273	-87	301	318	-42	249	3	3	140	48	48	210
274	-86	24	319	-41	95	4	4	0	49	49	90
275	-85	111	320	-40	193	5	5	135	50	50	276
276	-84	160	321	-39	137	6	6	44	51	51	193
277	-83	72	322	-38	99	7	7	42	52	52	157
278	-82	60	323	-37	122	8	8	17	53	53	129
279	-81	8	324	-36	86	9	9	24	54	54	109
280	-80	50	325	-35	89	10	10	16	55	55	127
281	-79	41	326	-34	56	11	11	46	56	56	230
282	-78	119	327	-33	92	12	12	0	57	57	164
283	-77	47	328	-32	21	13	13	0	58	58	226
284	-76	192	329	-31	77	14	14	80	59	59	207
285	-75	58	330	-30	131	15	15	49	60	60	162
286	-74	32	331	-29	228	16	16	106	61	61	74
287	-73	19	332	-28	223	17	17	0	62	62	74
288	-72	106	333	-27	60	18	18	25	63	63	53
289	-71	24	334	-26	71	19	19	90	64	64	175
290	-70	30	335	-25	144	20	20	46	65	65	192
291	-69	12	336	-24	112	21	21	80	66	66	231
292	-68	100	337	-23	49	22	22	39	67	67	340
293	-67	24	338	-22	0	23	23	98	68	68	162
294	-66	169	339	-21	96	24	24	85	69	69	136
295	-65	15	340	-20	71	25	25	39	70	70	138
296	-64	120	341	-19	62	26	26	99	71	71	279
297	-63	86	342	-18	114	27	27	30	72	72	210
298	-62	87	343	-17	44	28	28	58	73	73	149
299	-61	118	344	-16	28	29	29	23	74	74	201
300	-60	180	345	-15	93	30	30	42	75	75	153
301	-59	40	346	-14	52	31	31	26	76	76	195
302	-58	133	347	-13	31	32	32	85	77	77	179
303	-57	264	348	-12	26	33	33	70	78	78	121
304	-56	82	349	-11	41	34	34	159	79	79	262
305	-55	180	350	-10	0	35	35	49	80	80	174
306	-54	294	351	-9	109	36	36	118	81	81	159
307	-53	218	352	-8	28	37	37	38	82	82	49
308	-52	274	353	-7	38	38	38	184	83	83	154
309	-51	342	354	-6	47	39	39	193	84	84	120
310	-50	205	355	-5	18	40	40	6	85	85	96
311	-49	305	356	-4	20	41	41	126	86	86	97
312	-48	185	357	-3	174	42	42	160	87	87	146
313	-47	293	358	-2	47	43	43	133	88	88	112
314	-46	263	359	-1	0	44	44	24	89	89	159
315	-45	453	360	0	51	45	45	85	90	90	294

EMPIRICAL STRIKE FREQUENCY ANALYSIS.

S. Dakota lineaments length weighted

10 LEVELS OF FREQUENCY AT 101 PER LEVEL.

PERCENT AZIMUTH FOR SMOOTHING = 1.67

NO. OF DATA = 20490

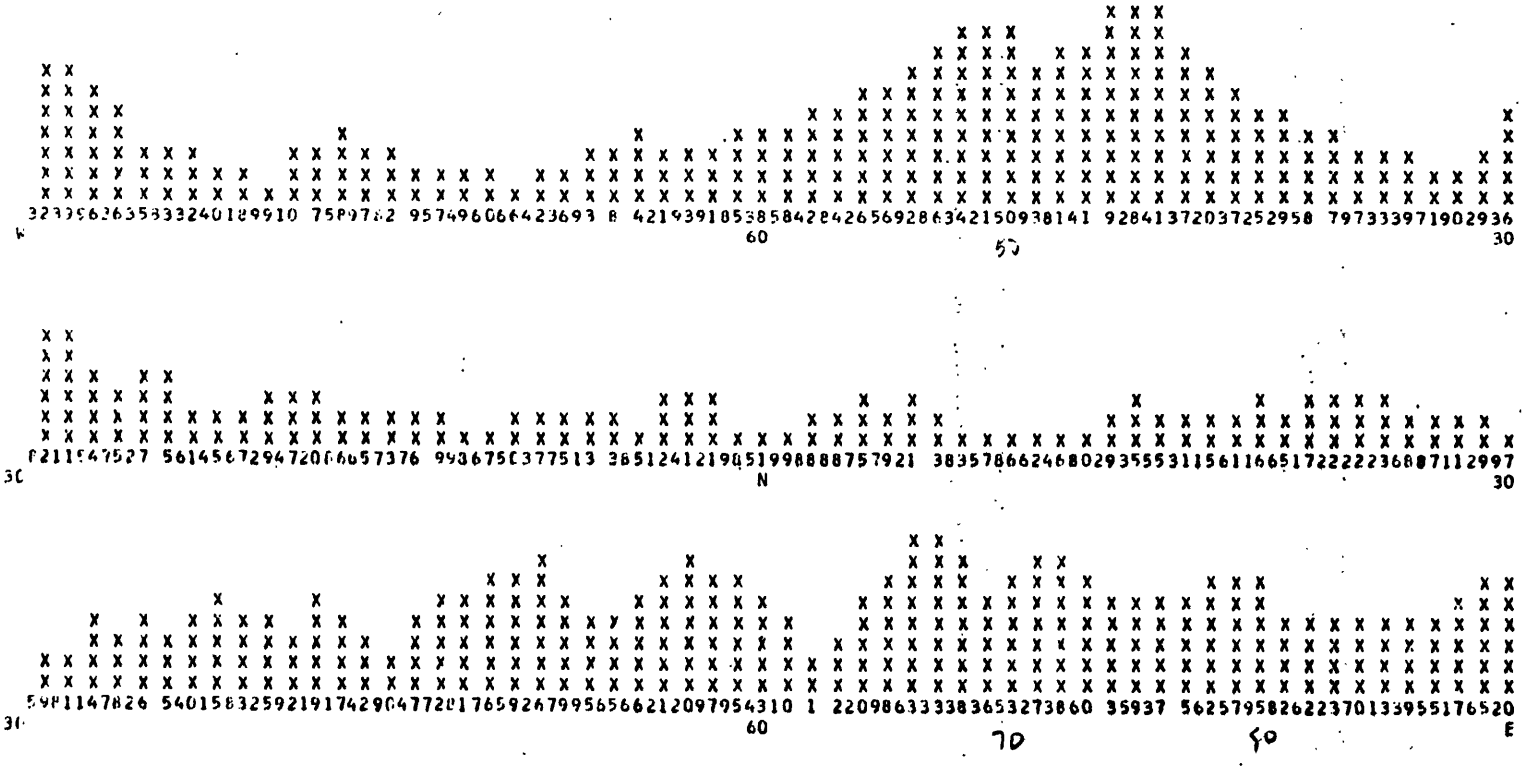

TABLE OF AZIMUTH VS FREQUENCY FOR PRECEDING STRIKE FREQUENCY PLOT

AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ	AZIM	BRNG	FREQ
271	-89	632	315	-44	941	1	1	99	46	46	347
272	-88	639	317	-43	737	2	2	168	47	47	472
273	-87	598	318	-42	620	3	3	168	48	48	481
274	-86	436	319	-41	537	4	4	275	49	49	576
275	-85	235	320	-40	425	5	5	179	50	50	559
276	-84	283	321	-39	429	6	6	221	51	51	626
277	-83	232	322	-38	358	7	7	103	52	52	479
278	-82	140	323	-37	307	8	8	83	53	53	395
279	-81	118	324	-36	297	9	9	57	54	54	365
280	- 0	99	325	-35	233	10	10	86	55	55	466
281	-79	210	326	-34	239	11	11	62	56	56	521
282	-78	207	327	-33	171	12	12	46	57	57	620
283	-77	356	328	-32	190	13	13	80	58	58	597
284	-76	297	329	-31	229	14	14	129	59	59	595
285	-75	282	330	-30	436	15	15	235	60	60	443
286	-74	109	331	-29	582	16	16	155	61	61	310
287	-73	157	332	-28	511	17	17	131	62	62	201
288	-72	149	333	-27	354	18	18	115	63	63	302
289	-71	160	334	-26	275	19	19	161	64	64	420
290	-70	66	335	-25	327	20	20	216	65	65	598
291	-69	142	336	-24	305	21	21	165	66	66	763
292	-68	136	337	-23	161	22	22	217	67	67	733
293	-67	293	338	-22	145	23	23	222	68	68	638
294	-66	209	339	-21	167	24	24	222	69	69	436
295	-65	304	340	-20	229	25	25	223	70	70	953
296	-64	221	341	-19	247	26	26	168	71	71	627
297	-63	293	342	-18	220	27	27	187	72	72	638
298	-62	291	343	-17	186	28	28	111	73	73	560
299	-61	389	344	-16	165	29	29	129	74	74	583
300	-60	338	345	-15	173	30	30	97	75	75	459
301	-59	35	346	-14	176	31	31	159	76	76	437
302	-58	442	347	-13	109	32	32	181	77	77	405
303	-57	434	348	-12	98	33	33	314	78	78	562
304	-56	520	349	-11	67	34	34	278	79	79	557
305	-55	556	350	-10	150	35	35	326	80	80	595
306	-54	692	351	-9	137	36	36	205	81	81	382
307	-53	736	352	-8	175	37	37	340	82	82	362
308	-52	834	353	-7	113	38	38	415	83	83	323
309	-51	821	354	-6	103	39	39	383	84	84	370
310	-50	859	355	-5	85	40	40	325	85	85	313
311	-49	693	356	-4	212	41	41	292	86	86	339
312	-48	781	357	-3	241	42	42	419	87	87	375
313	-47	741	358	-2	221	43	43	317	88	88	417
314	-46	1009	359	-1	98	44	44	242	89	89	565
315	-45	928	360	0	51	45	45	190	90	90	520

271 - 271
302 - 321
330 - 332
38 - 39
42
47 - 53
55 - 60
64 - 81
88 - 90

5. records [illegible] [illegible] omitted

FREQUENCY PROBABILITY DATA

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FREQUENCY MEAN = 341.5

EFF. FRE..	REL. FREQ.	FREQ. PROB.	SIGNIF VALUE
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312	2.0	0.006	89.7
313	2.0	0.007	87.4
314	2.0	0.007	86.0
315	2.0	0.008	84.4
316	2.0	0.008	82.8
317	2.0	0.009	81.0
318	2.1	0.010	79.0
31	2.1	0.010	76.9
32.	2.1	0.011	74.7
321	2.1	0.012	72.4
322	2.1	0.013	69.9
323	2.1	0.013	67.2
324	2.1	0.014	64.4
325	2.1	0.015	61.5
326	2.1	0.015	58.4
327	2.1	0.016	55.2
32	2.1	0.017	51.9
32	2.1	0.017	48.4
33.	2.1	0.018	44.9
331	2.1	0.019	41.1
332	2.1	0.019	37.3
333	2.1	0.020	33.4
334	2.1	0.020	29.4
335	2.1	0.020	25.4
336	2.1	0.021	21.2
337	2.1	0.021	17.1
33	2.1	0.021	12.8
339	2.2	0.021	8.6
340	2.2	0.022	4.3
341	2.2	0.022	0.0
342	2.2	0.022	-4.4
343	2.2	0.021	-8.8
344	2.2	0.021	-13.1
345	2.2	0.021	-17.4
346	2.2	0.021	-21.6
347	2.2	0.020	-25.6
348	2.2	0.020	-29.6
349	2.2	0.019	-33.5
350	2.2	0.019	-37.4
351	2.2	0.018	-41.2
352	2.2	0.018	-44.8
353	2.2	0.017	-48.4
354	2.2	0.016	-51.8
355	2.2	0.016	-55.0
356	2.2	0.015	-58.2
357	2.2	0.014	-61.2
358	2.3	0.014	-64.1
359	2.3	0.013	-66.9
360	2.3	0.012	-69.4
361	2.3	0.011	-71.9
362	2.3	0.011	-74.1
363	2.3	0.010	-76.3
364	2.3	0.009	-78.3
365	2.3	0.009	-80.3
366	2.3	0.008	-82.0
367	2.3	0.008	-83.7
368	2.3	0.007	-85.2
369	2.3	0.007	-86.6
370	2.3	0.006	-87.8
371	2.3	0.006	-89.0