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REGRESSION ANALYSIS OF EARTHQUAKE MAGNITUDE AND SURFACE FAULT LENGTH USING THE 1970 DATA OF BONILLA AND BUCHANAN

(preliminary report)

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This report is preliminary and
has not been edited or reviewed
for conformity with Geological
Survey standards and nomenclature.

Menlo Park, California

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Introduction. The report of Bonilla and Buchanan (1970) includes regressions of fault length on earthquake magnitude that can be used to estimate most probable length of surface rupture given earthquake magnitude. Those regressions, however, have sometimes been incorrectly used to estimate magnitude from fault length, as pointed out by Mark (1977).

Using the data of Bonilla and Buchanan, this report gives regressions of earthquake magnitude on length of surface rupture that can be correctly used to estimate most probable magnitude if the length of surface rupture is given. It also gives the regressions of length of rupture on magnitude that can be used to estimate most probable length of rupture given earthquake magnitude.

In table 1 and figures 1-5 the numbering and lettering system used to designate fault geography and fault types is the same as in Bonilla and Buchanan (1970). Numbers 1-49 include surface ruptures that occurred in North America and numbers 50-140 include ruptures outside of North America. The fault types are indicated by letters as follows: A, normal-slip faults; B, reverse-slip faults; C, normal oblique-slip faults; D, reverse oblique-slip faults; and E, strike-slip faults.

Use of the regression lines. The regression of log length on magnitude

(Log L=a+bM) can be used to estimate the most probable rupture length given magnitude, and the regression of magnitude on log length (M=a+b Log L) can be used to estimate the most probable magnitude given rupture length. The estimation of 'maximum magnitudes' for a given rupture length requires the use of one-sided confidence limits (Mark, 1977).

References cited

Bonilla, M. G., and Buchanan, J. M., 1970, Interim report on world wide historic surface faulting: U.S. Geol. Survey open-file rept., 32 p.

Mark, R. K., 1977, Application of linear statistical models of earthquake magnitude versus fault length in estimating maximum expectable earthquakes: Geology, in press.

Table 1

Regression analysis of magnitude - surface rupture length data from Bonilla and Buchanan (1970).

				Log(L)=a+b*M			M=a+b*Log(L)		
set	n	r^2	f	a	b	s	a	b	s
1-49	20	0.372	10.64	-0.91	0.35	0.51	5.23	1.08	0.90
50-140	33	0.217	8.57	-1.49	0.40	0.55	6.56	0.54	0.64
1-140	53	0.257	17.62	-0.96	0.34	0.53	6.03	0.76	0.80
A	14	0.175	2.55	-0.69	0.28	0.45	6.19	0.63	0.68
B	7	0.003	0.01	not significant					
C	7	0.459	4.24	-2.81	0.61	0.38	6.08	0.75	0.42
D	5	0.006	0.02	not significant					
E	20	0.484	16.87	-1.08	0.39	0.52	4.96	1.24	0.93
A+C	21	0.279	7.37	-1.46	0.40	0.45	6.13	0.70	0.59
B+D	12	0.033	0.34	not significant					
C+D+E	32	0.367	17.42	-1.24	0.40	0.55	5.62	0.93	0.84
C+D	12	0.230	2.99	-2.79	0.59	0.57	6.62	0.39	0.47
B+E	27	0.299	10.65	-0.71	0.32	0.56	5.71	0.94	0.97
A+C+E	41	0.380	23.94	-1.20	0.39	0.49	5.56	0.99	0.79
B+D+E	32	0.251	10.07	-0.81	0.32	0.60	5.98	0.78	0.93

Notes

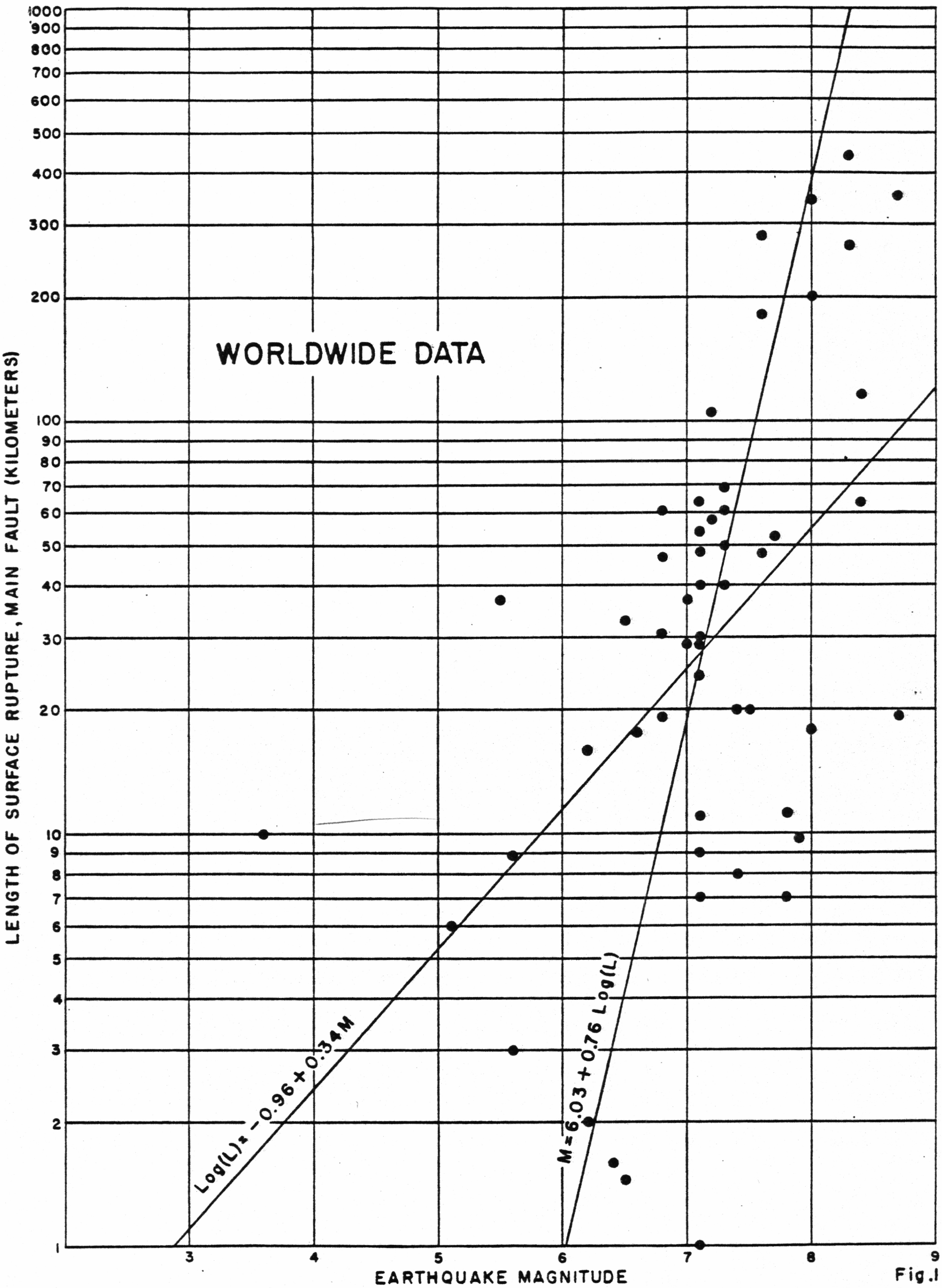
"n" is the number of cases.

"r^2" is the fraction of the variance explained by the regression. It ranges from 0 (no linear relationship) to 1 (perfect linear relationship).

"f" is a measure of statistical significance of the regression and is equal to $r^2/((1-r^2)(n-2))$.

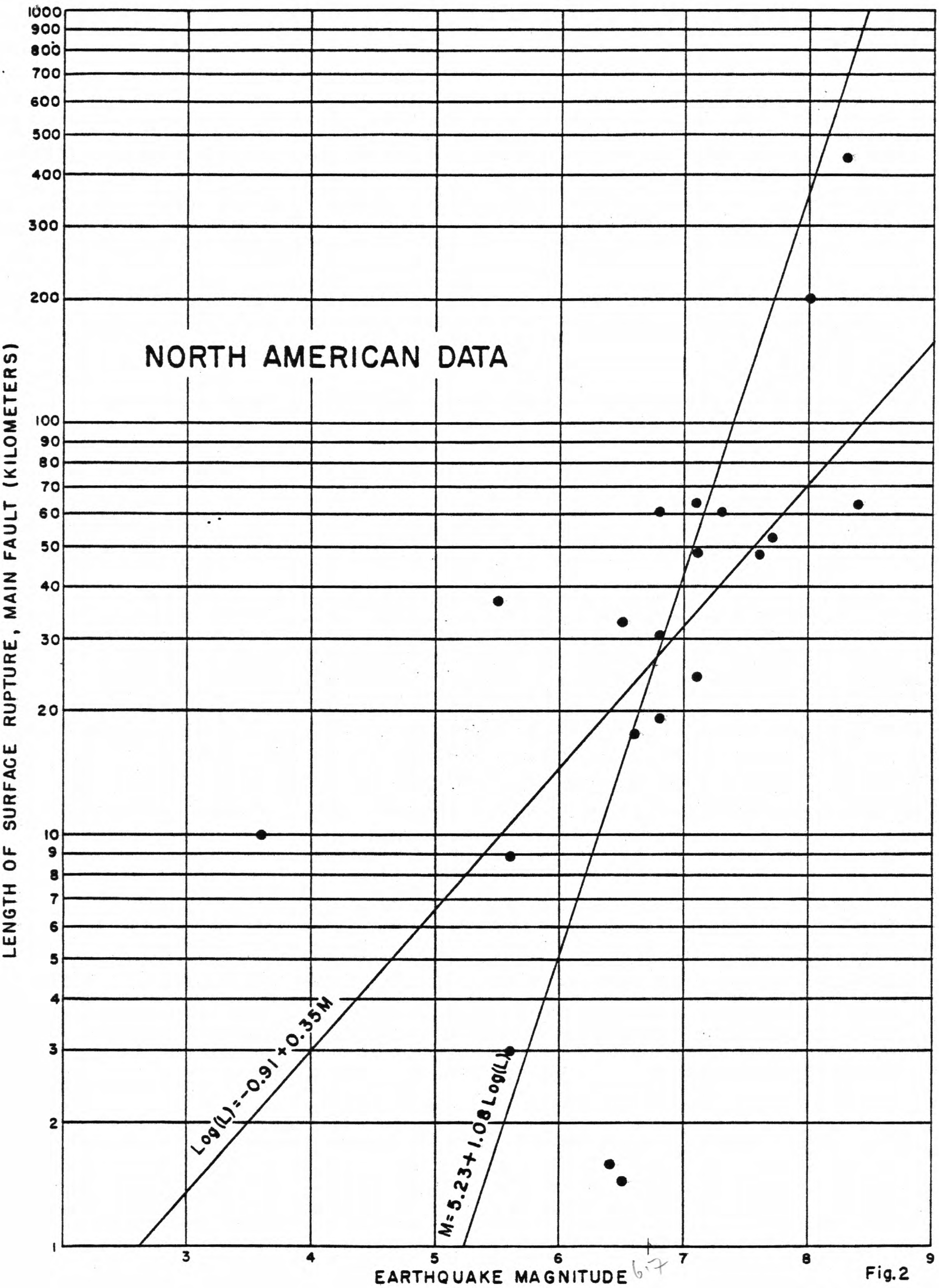
"L" is in kilometers.

"s" is the standard error of the estimate. s^2 is equal to the residual sum of square errors about the regression line divided by the degrees of freedom (i.e., n-2).



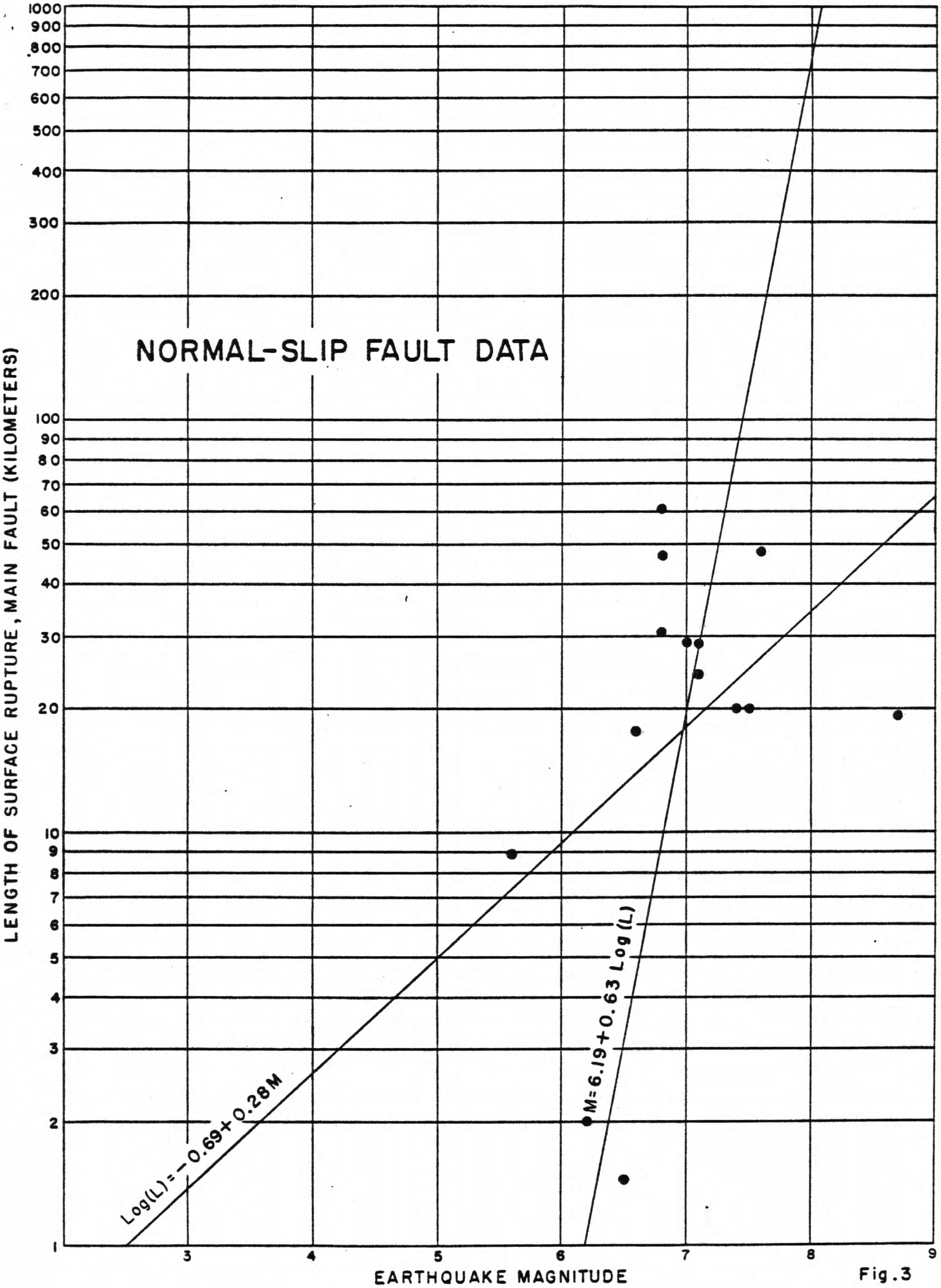
WORLDWIDE DATA
LENGTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS)
EARTHQUAKE MAGNITUDE
Log(L) = -0.96 + 0.34M
M = 6.03 + 0.76 Log(L)

Fig. I



NORTH AMERICAN DATA
LENGTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS)
EARTHQUAKE MAGNITUDE
Log(L)=-0.91+0.35M
M=5.23+1.08 Log(L)

Fig. 2



NORMAL-SLIP FAULT DATA
LENGTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS)
EARTHQUAKE MAGNITUDE
Log(L)=-0.69+0.28M
M=6.19+0.63 Log(L)
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
3
4
5
6
7
8
9

Fig.3

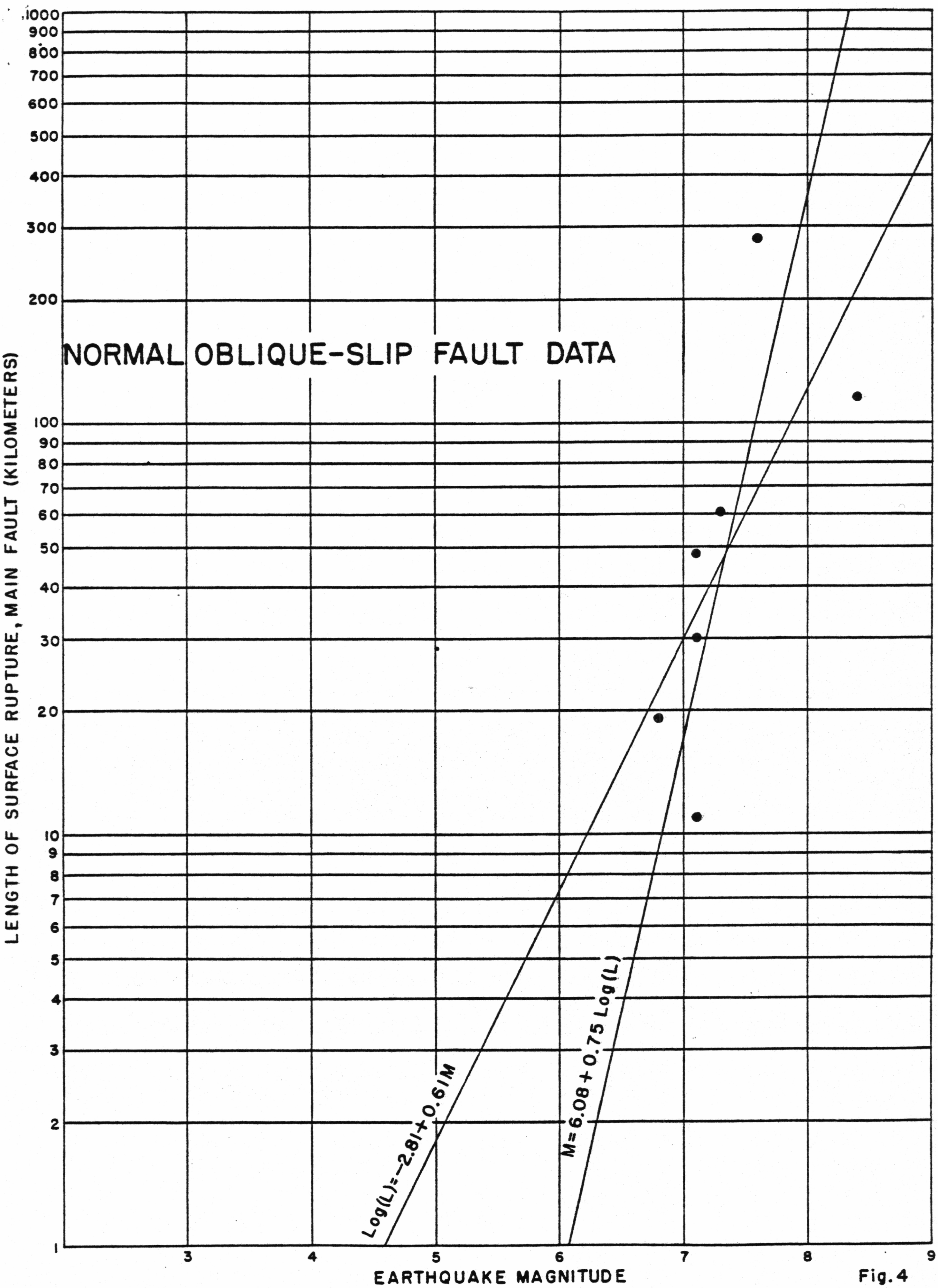
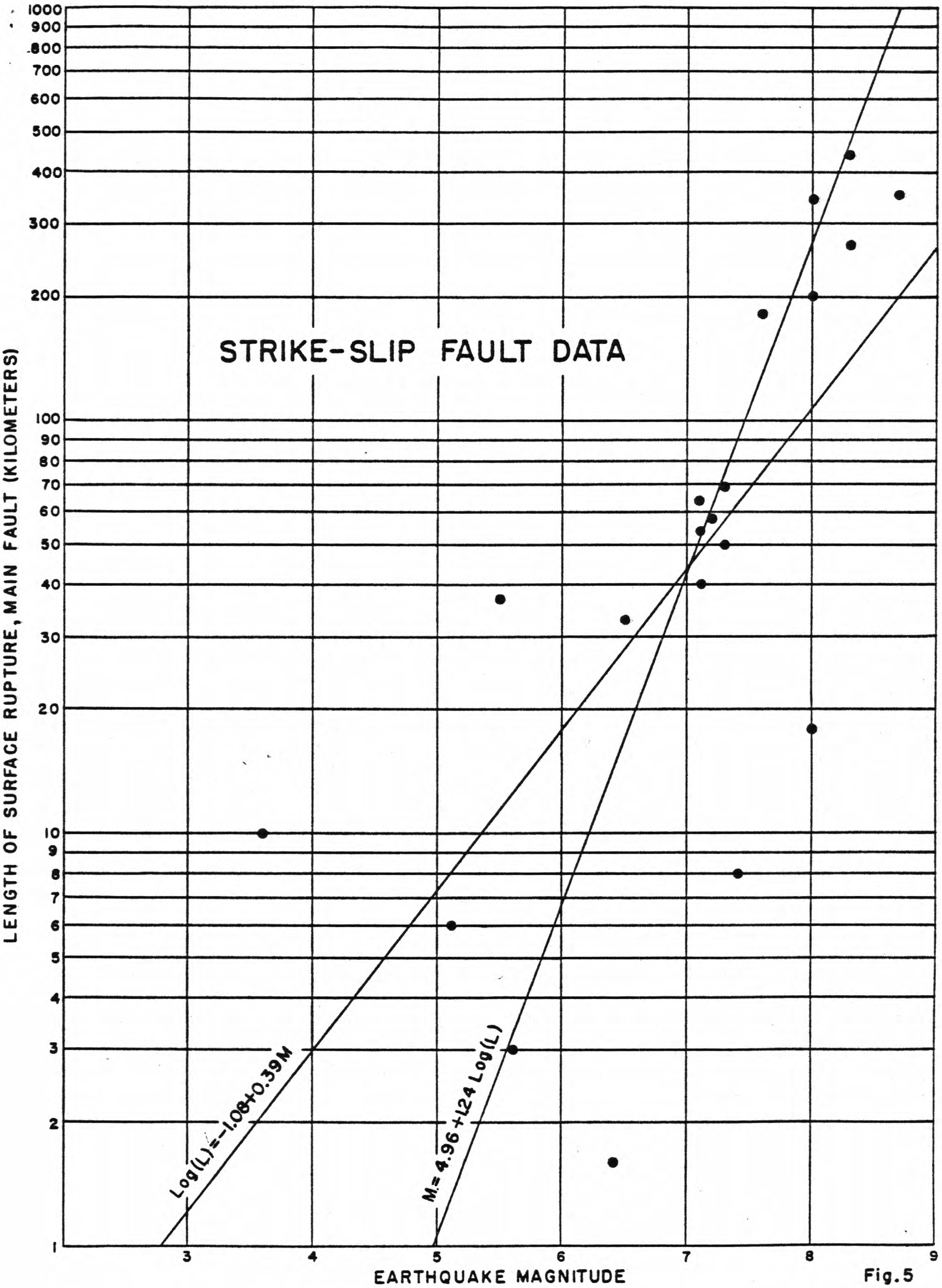

NORMAL OBLIQUE-SLIP FAULT DATA
LENGTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS)
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
3
4
5
6
7
8
9
Log(L)=-2.81+0.61M
M=6.08+0.75 Log(L)
EARTHQUAKE MAGNITUDE

Fig. 4



STRIKE-SLIP FAULT DATA
LENGTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS)
EARTHQUAKE MAGNITUDE
Log(L)=-1.08+0.39M
M=4.96+1.24 Log(L)
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
3
4
5
6
7
8
9

Fig. 5