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

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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


Table 1
Regression analysis of magnitude - surface rupture length data from Bonilla and Buchanan (1970).

<table>
<thead>
<tr>
<th>Set</th>
<th>n</th>
<th>r²</th>
<th>f</th>
<th>a</th>
<th>b</th>
<th>s</th>
<th>a</th>
<th>b</th>
<th>s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-49</td>
<td>20</td>
<td>0.372</td>
<td>10.64</td>
<td>-0.91</td>
<td>0.35</td>
<td>0.51</td>
<td>5.23</td>
<td>1.08</td>
<td>0.90</td>
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<tr>
<td>50-140</td>
<td>33</td>
<td>0.217</td>
<td>8.57</td>
<td>-1.49</td>
<td>0.40</td>
<td>0.55</td>
<td>6.56</td>
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<td>1-140</td>
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<td>0.257</td>
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<td>-0.96</td>
<td>0.34</td>
<td>0.53</td>
<td>6.03</td>
<td>0.76</td>
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<tr>
<td>A</td>
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<td>-0.69</td>
<td>0.28</td>
<td>0.45</td>
<td>6.19</td>
<td>0.63</td>
<td>0.68</td>
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<tr>
<td>B</td>
<td>7</td>
<td>0.003</td>
<td>0.01</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>0.459</td>
<td>4.24</td>
<td>-2.81</td>
<td>0.61</td>
<td>0.38</td>
<td>6.08</td>
<td>0.75</td>
<td>0.42</td>
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<tr>
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<td>0.02</td>
<td>not significant</td>
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<td></td>
<td></td>
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<tr>
<td>E</td>
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<td>0.484</td>
<td>16.87</td>
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<td>0.39</td>
<td>0.52</td>
<td>4.96</td>
<td>1.24</td>
<td>0.93</td>
</tr>
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<td>0.45</td>
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<tr>
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<td>0.033</td>
<td>0.34</td>
<td>not significant</td>
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<td>C+D+E</td>
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<td>0.39</td>
<td>0.49</td>
<td>5.56</td>
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<td>0.79</td>
</tr>
<tr>
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<td>10.07</td>
<td>-0.81</td>
<td>0.32</td>
<td>0.60</td>
<td>5.98</td>
<td>0.78</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Notes

"n" is the number of cases.

"r²" 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 r²/((1-r²)(n-2)).

"L" is in kilometers.

"s" is the standard error of the estimate. s² is equal to the residual sum of square errors about the regression line divided by the degrees of freedom (i.e., n-2).
NORTH AMERICAN DATA

LENTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS) vs EARTHQUAKE MAGNITUDE

\[ \log(L) = -0.91 + 0.35M \]

\[ M = 0.23 + 1.0 \log(L) \]
NORMAL-SLIP FAULT DATA

Fig. 3

Log(L) = 0.69 + 0.28M

EARTHQUAKE MAGNITUDE

LENGTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS)
NORMAL OBLIQUE-SLIP FAULT DATA

LENGTH OF SURFACE RUPTURE, MAIN FAULT (KILOMETERS)

EARTHQUAKE MAGNITUDE

Log(L) = 2.8 + 0.6M
M = 6.08 + 0.75 Log(L)

Fig. 4