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Comment and Reply

Comment on "A Reappraisal of Large Earthquake Scaling" by C. Scholz

by Barbara Romanowicz

In a recent article, Romanowicz (1992) showed that for large strike-slip earthquakes for which the width W of the fault is equal to the thickness of the brittle zone, the moment-length relation can be described by a relation of the type

$$M_0 = \alpha L, \tag{1}$$

where M_0 is seismic moment, L is the length of the fault, and α is a proportionality coefficient. This relation implies that the average slip on the fault grows like W. This is compatible with dislocation models of the source, but not with the "L-model" proposed by Scholz (1982), for which one would expect, instead of (1),

$$M_0 = \alpha L^2. \tag{2}$$

Scholz (1994) has challenged the results of Romanowicz (1992), arguing that there is no reason to distinguish strike-slip earthquakes from other types of earthquakes. He shows that the global dataset consisting of interplate strike-slip earthquakes and all intraplate earthquakes of moment between $0.01 * 10^{20}$ N-m and $10 * 10^{20}$ N-m is well described by relation (2). In this analysis, large interplate subduction zone earthquakes are not considered.

The disagreement between Scholz (1994) and Romanowicz (1992) resides primarily in a fundamental difference in the definition a "large earthquake." Both authors distinguish large and small earthquakes by whether or not the width of the fault W has attained its maximum size W_0, determined by the thickness h of the brittle zone and the dip of the fault. For strike-slip earthquakes on vertical faults, $W_0 \sim h$.

Scholz's (1994) basic assumption is that earthquakes grow with an aspect ratio (L/W) of 1, so that large strike-slip earthquakes are those for which L is equal or greater than h, which globally is on the order of 10 to 25 km on transform boundaries. In this sense, all the earthquakes considered in the study of Romanowicz (1992) are indeed large, since their length exceeds 15 to 20 km.

Scholz (1994) then proceeds to determine whether the dataset of "large" earthquakes considered is better fit by $n = 2$ or $n = 1$ in the relation: $M_0 = \alpha L^n$, where $n = 1$ corresponds to the "W-model" and $n = 2$ to the "L-model". It is clear that the data favor a relation with $n = 2$, since in order to accomodate both events of moments as small as $0.01 * 10^{20}$ N-m and as large as $8 * 10^{20}$ N-m, the standard deviation of the $n = 1$ relation, as depicted by the width of the band containing the data and bounded by $n = 1$ lines, would be much larger than for the $n = 2$ relation.

There is no compelling reason, however, why the aspect ratio of earthquakes of growing size should be $\sim$1. In fact, global compilations indicate that this ratio is between 2 and 4 (e.g., Purcaru and Berckhemer, 1982). In this case, the limit between "small earthquakes" and "large earthquakes" lies somewhere in the range of moments $0.1 * 10^{20}$ to $1.0 * 10^{20}$ N-m. Romanowicz (1992) chooses not to specify that limit at the onset. She singles out strike-slip earthquakes on quasi-vertical transcurrent faults in order to work with a global dataset for which the saturation width W_0 is confined within a narrow range, namely on the order of 10 to 25 km worldwide. This is the only global dataset of sufficient size, at present, for which a break in scaling due to the saturation, occurring within a narrow range of seismic moments, is likely to be observable.

Romanowicz (1992) notes, following many previous observations, that most strike-slip earthquakes [excluding the Japanese intraplate data of Shimazaki (1986)] plot on the low-stress-drop side ($\Delta\sigma \sim$ 10 to 30 bars) of the total global dataset (Fig. 1) and that the largest ones, with moments between $1 * 10^{20}$ and $10 * 10^{20}$ N-m, depart from a general trend well described by a relation of the type $M_0 = \alpha L^3$. She finds that the dataset consisting of low-stress-drop strike-slip earthquakes on vertical transcurrent faults is best fit by a relation $M_0 = \alpha L^3$ for $M_0 <$ 0.6 to $0.8 * 10^{20}$ N-m, and $M_0 = \alpha L$ for $M_0 >$ 0.6 to $0.8 * 10^{20}$ N-m. The standard deviation of the fit is more than twice as large when a fit of the form $M_0 = \alpha L^2$ is tried on this dataset. Using the relation

$$M_0 = \pi/2 \Delta\sigma L W^2, \tag{3}$$

she finds that the locus of the break in slope implies a saturation width W_0 of 10 to 25 km, consistent with what is expected for transform faults in oceanic or continental settings.

Three recent large strike-slip events (Alaska, 11/30/87 and 03/06/88, and Macquarie, 05/23/89) remain exceptions to this trend (Fig. 1), even after modifying their lengths according to Scholz (1993). We interpret them as not belonging to the same class, either because

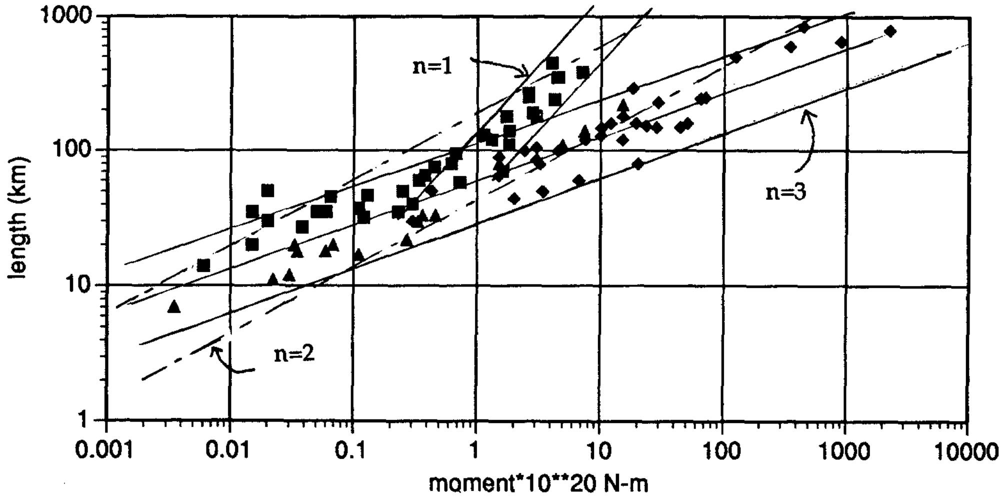

Figure 1. Moment-length relations for the available global dataset of earthquakes of moments larger than $0.5 * 10^{18}$ N-m. We distinguish the low-stress-drop strike-slip dataset of Romanowicz (1992) (squares), other strike-slip earthquakes comprising the Japanese intraplate collection of Shimazaki (1986) and several unusual recent events (Alaska, 11/30/87, 03/06/88; Macquarie, 05/23/89) (triangles), and interplate as well as intraplate thrust events (diamonds). The data are the same as used in Romanowicz (1992), with the additions and modifications suggested by Scholz (1993). The broken lines are the $n = 2$ lines of Figure 1 in Scholz (1993).

of exceptionally high stress drop (Alaska, 11/30/87, 03/06/88, e.g., Hwang and Kanamori, 1992) or because of an exceptionally thick width of the rupture (Macquarie, 05/23/89, e.g., Ekstrom and Romanowicz, 1990).

The class of strike-slip earthquakes considered by Romanowicz (1993) contains both interplate and intraplate earthquakes, and the complementary class (Fig. 1) comprises both interplate thrust as well as intraplate earthquakes in Japan and normal faulting events of Scholz *et al.* (1986). Given the several free parameters in this type of study (stress drop, width, underlying physics), we feel it is preferable to derive implications for the physics based on a dataset for which the other parameters are approximately constant. The class of strike-slip earthquakes of low stress drop is the only such class. The analysis of moment-length data pertaining to these earthquakes favors the "*W*-model".

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