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Reply to Comment on "On Scaling Relations for Large Earthquakes by Romanowicz and Rundle" From the Perspective of a Recent Non-Linear Diffusion Equation Linking Short-Time Deformation to Long-Time Tectonics

by Barbara Romanowicz and John Rundle

In their comment, Sornette and Sornette propose an adaptation of their original theory (Sornette and Virieux, 1992) to the case of a single fault, in response to the note by Romanowicz and Rundle (1993) who had remarked that the theory was not applicable to the case when one of the dimensions of the fault (the width W) saturated. Sornette and Sornette (1993) argue that Romanowicz and Rundle's argument was incorrect.

Let us clarify this point. The form of the probability distribution in equation (5) is obtained both in Sornette and Virieux (1992) and Sornette and Sornette (1993) under the assumption that "there is a linear relation between deformation ϵ (mean slip) and fault rupture length l." In itself, this assumption contains the premise that the "L-model" of Scholtz (1982) is valid, and it is not surprising therefore that their self-consistent treatment of the problem, starting from this hypothesis, leads to b values that are consistent with the "L-model."

If, on the contrary, we make the assumption that, for large earthquakes, slip scales linearly with width (which is consistent with dislocation models), then expression (5) needs to be replaced by

$$P(\epsilon)\, d\epsilon \sim \epsilon^{-1-m'}\, d\epsilon, \qquad (1)$$

where now $m' = (\alpha b/c)/\zeta$ and ζ is as defined by Sornette and Sornette in their equation (3).

If we use m' instead of m in equation (5) of Sornette and Sornette (1993) and follow through their argumentation, then, everything else staying the same, we infer that $m' = 2$. Therefore, with $\zeta = 1/2$ (Sornette and Virieux, 1992) and $c = 1.5$, $\alpha = 1$ implies $b = 1.5$ and vice versa, in agreement with observations for large earthquakes and the "W-model."

Of course, if W saturates, $\zeta \rightarrow 0$ and m' is undefined, so that the probability density in equation (1) has no meaning.

In short, by introducing the power law in equation (5), the authors put in the answer they are looking for "by hand."

Ultimately, the real question still remains, whether slip scales with length or width of the fault or any other relevant geometric parameter, and, while dislocation theory as well as recent observations (Romanowicz, 1992) favor width, we still need on the order of at least 5 to 10 well-instrumented observations of earthquakes of magnitude larger than 8 to confirm or deny this.

As for the tiling arguments, Rundle (1989) did not imply that his tiling scheme was unique.

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