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Discussion

Reply to the comment by P. Gillespie on "The geometric and statistical evolution of normal fault systems: an experimental study of the effects of mechanical layer thickness on scaling laws"☆

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1. Introduction

This reply to Gillespie's comment (Gillespie, 2003) on our paper "The geometric and statistical evolution of normal fault systems: an experimental study of the effects of mechanical layer thickness on scaling laws" is meant to clarify two main issues he raised—specifically, the scale dependence of one of the techniques used to measure the spatial distribution of faults, and the statistical uncertainty of the cluster analysis. I welcome the constructive criticism and vigorous discussion of our work.

2. Re: C_v vs. r

Gillespie's description of our method is correct, and our use of it *as described* in the original paper is indeed incorrect. The analysis of these data were performed in 1997–1998, and we did not formally use an alternative technique that employs a coefficient of variation (Cox and Lewis, 1966, as discussed by Gillespie in his comment and earlier work (Gillespie et al., 1999, 2001)). However, we did consider the scale-dependent nature of using a standard deviation as a measure of how regularly spaced faults are. We did this by normalizing the standard deviation of the spacings to the average spacing (as described by Gillespie). This was done as a quality-control check during the analysis, but not included in the manuscript.

3. Re: Fig. 14A

Gillespie (this issue) is also correct in pointing out that the generalized trend of r in Fig. 14A in Ackermann et al. (2001) is reversed from that shown in Fig. 1b in Ackermann et al. (2001), a drafting error on my part. The corrected version of the figure is provided here (Fig. 1).

4. Re: Statistical uncertainty and sample size

Gillespie raises the question of whether the faults in the experimental models are *significantly* anticlustered, as opposed to anticlustering observed in a random sample. Fig. 2 shows the results of applying the confidence levels calculated by Gillespie (this issue) to our fault data. Faults in the models are significantly clustered (C_v > 95th percentile for N) until power law length–displacement scaling begins

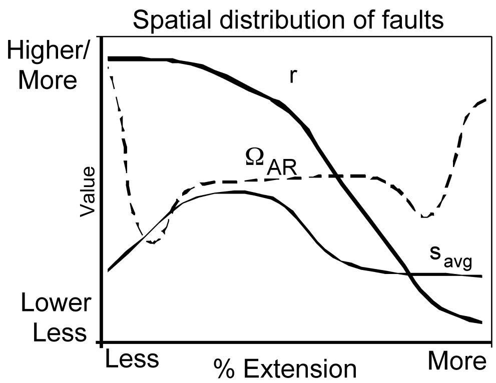

Fig. 1. Corrected version of Fig. 14A in Ackermann et al. (2001), showing r (standard deviation of fault spacings) decreasing with increasing extension, as faults become more regularly spaced. Normalized to the mean spacing (s_{avg}) as C_v, the data follow the same trend (see Gillespie, Fig. 1, this issue).

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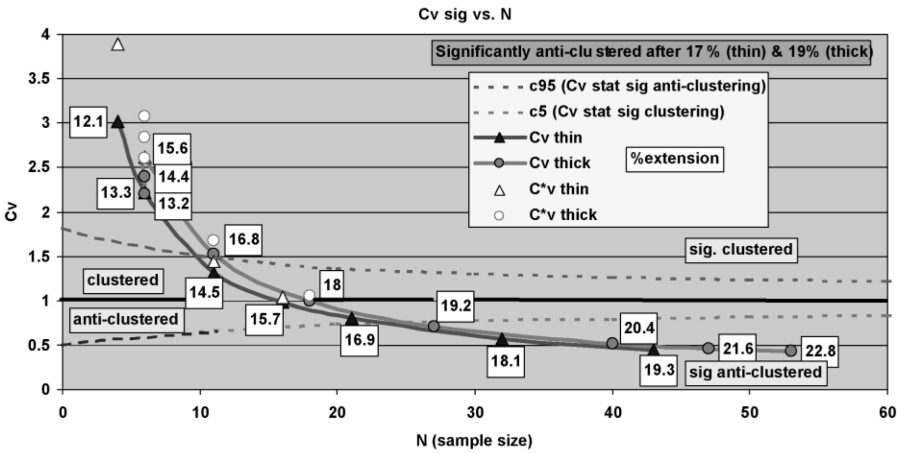

Fig. 2. Coefficient of variation (C_v) as a function of sample size (N), for both the thin and thick models discussed in Ackermann et al. (2001). Also shown are the 95% and 5% confidence intervals for clustering and anticlustering behavior. C_v at small sample sizes has been corrected to C_v^*. See text for discussion.

to break down. There is a transitional period where the faults are neither significantly clustered nor significantly anti-clustered, after which the faults are significantly anti-clustered. This analysis supports the results based on Ω, the nearest neighbor statistic, in Fig. 11 of Ackermann et al. (2001). Ω stabilizes at the same extension values as C_v enters the statistically significant anti-clustered region of Fig. 2.

Gillespie also raises the issue of the effect of sample size on C_v, following Borgos (1997). At small sample sizes C_v tends to a beta distribution (Borgos 1997, as referenced by Gillespie), and needs to be corrected as C_v should tend towards one, as for a Poisson process. This correction was applied for all samples discussed in Ackermann et al. (2001), and is shown in Fig. 2 as C_v^*. The results of the correction do not affect the interpretation of C_v (normalized r) in Ackermann et al. (2001).

5. Re: Multiple line samples

Gillespie correctly points out that parallel, multiple line samples can oversample the system if a balance between line frequency and fault length is not kept. This method may also *undersample* if that balance is not kept (lines placed at the edge of faulted areas, intersecting a low proportion of the faulted area). Our line samples were positioned such that they intersected at least 10% of the faults in the faulted area, and their spacing was $0.9L_{max}$, where L_{max} is the maximum fault length for a given extension increment. If a fault was intersected by more than one scanline, it was only counted for the scanline crossing the fault closest to its maximum displacement.

6. Conclusions

Ackermann et al. (2001) overlooked a method (Cox and Lewis, 1966; Gillespie et al., 1999, 2001) by which to express regularity of fault spacing, but rather followed the same procedure as a quality check during data analysis. It is not clear that the method is a more robust measure for this particular dataset. The uncertainty comments on Ackermann et al. (2001) were clarified in this reply. I appreciate the comments and insights provided by Gillespie (this issue) and look forward to future discussion of this work.

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