PS Spatial Scaling of Normal Faults, A-Bomb Canyon, Arizona*

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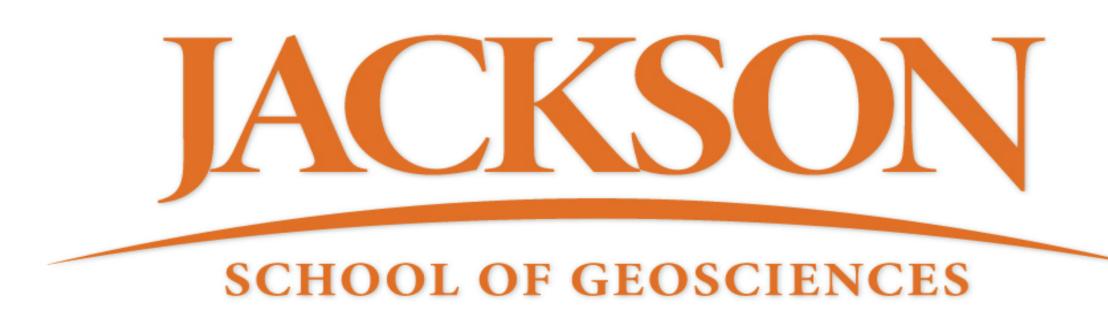
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Abstract

Understanding the spatial arrangement of structural features, such as faults, can lead to an understanding of whether the features are randomly located, clustered together, or anti-clustered in space. The objective of this project is to understand the spatial arrangement of normal faults in A-Bomb Canyon, in the Buckskin Mountains of Arizona. Previous spatial arrangement studies have included statistical analyses of nearest neighbor spacings (Priest and Hudson, 1976; Narr and Suppe, 1991) and box counting (Barton, 1995), which have been shown to have limited utility (Gomez and Marrett, in review). The normalized correlation count methodology (Marrett et al., in review) was utilized in this study in order to quantify the spatial organization of faults. In the process of studying the arrangement of these faults, the size distribution, coefficient of variation as well as the normalized correlation count will be examined in order to understand whether or not the faults are clustered or randomly spaced and, if they are clustered, whether those clusters show fractal scaling. Data were collected in the field along four different scanlines. Three of the scanlines are shorter in overall length, considered high resolution and focused on faults with displacements on the millimeter to larger scale. The fourth scanline, which is considerably longer, focused only on faults with displacements larger than a meter. Preliminary conclusions show that the size distribution of the faults follows a common power law on both the high resolution and low resolution scales. The high resolution correlation counts indicates that the faults are arranged in regularly spaced fractal clusters and the low resolution correlation count indicates self-organized clustering of faults. These analyses having different resolutions and length scales, will be compared in order to understand how observations on short scales (e.g. well bores) constrain features on long scales (e.g. oil fields).

^{*}Adapted from poster presentation given at 2017 AAPG Annual Convention & Exhibition, Houston, Texas, April 2-5, 2017

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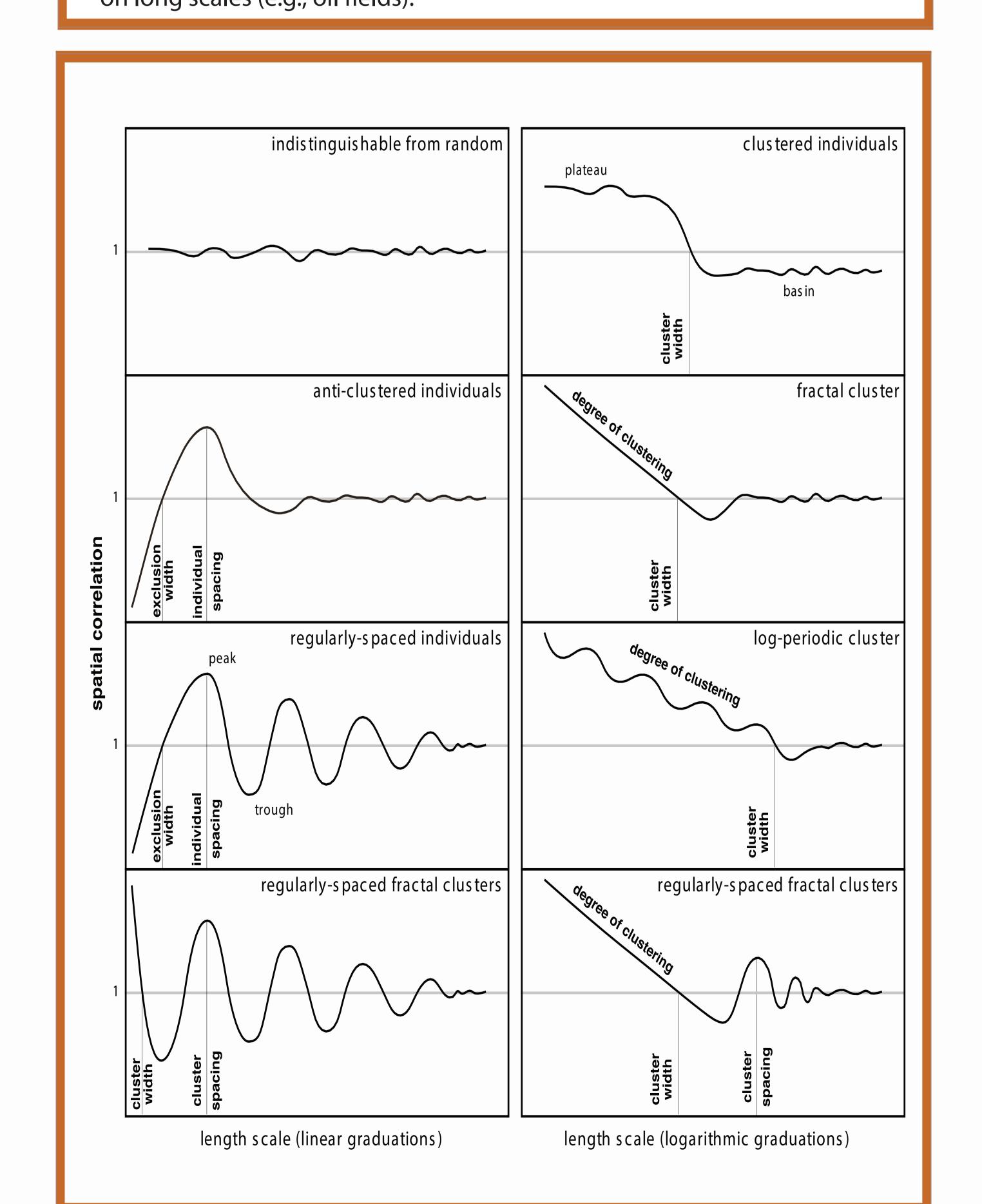


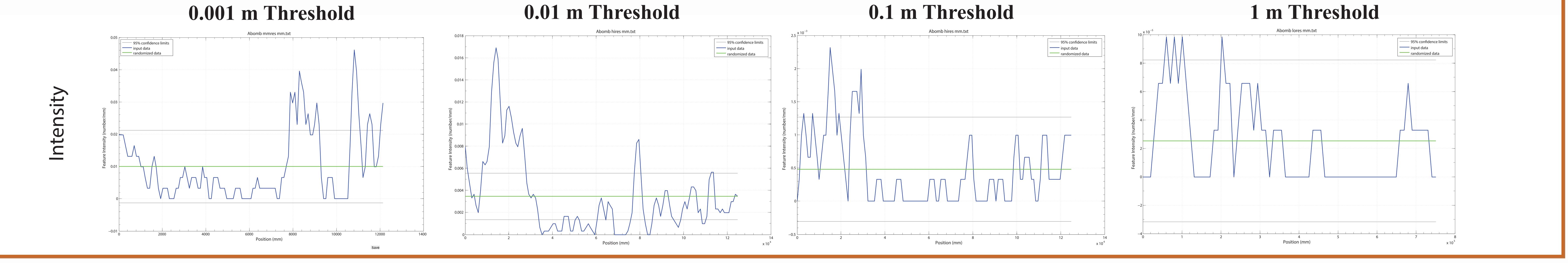
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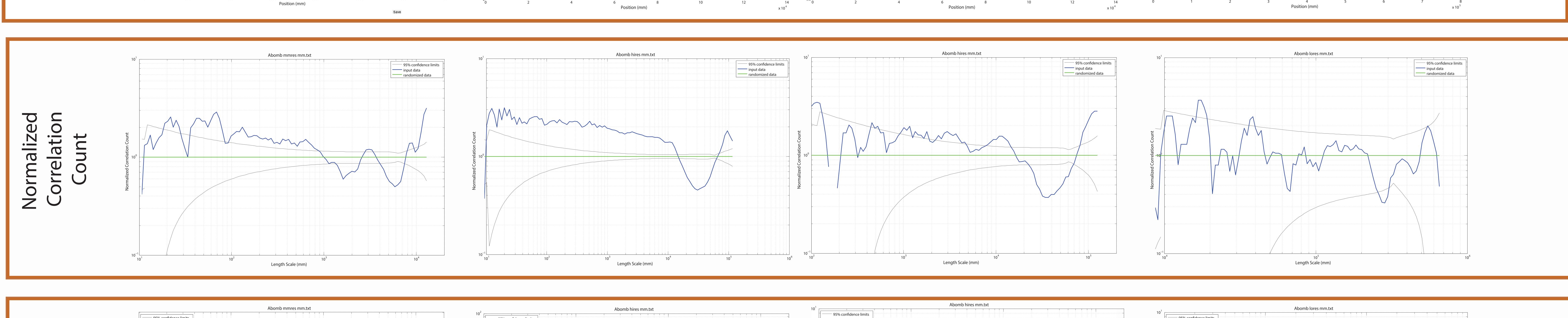
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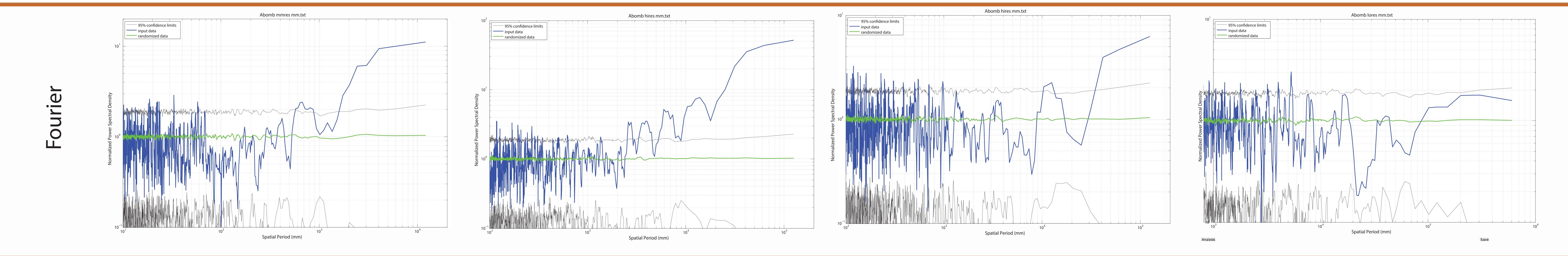
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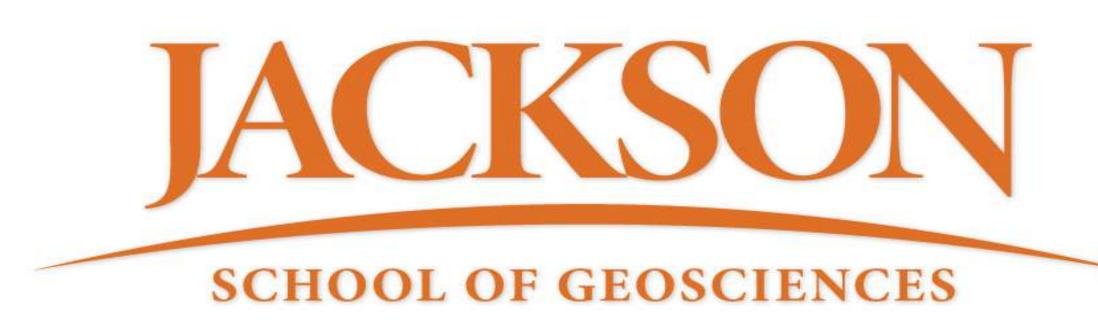
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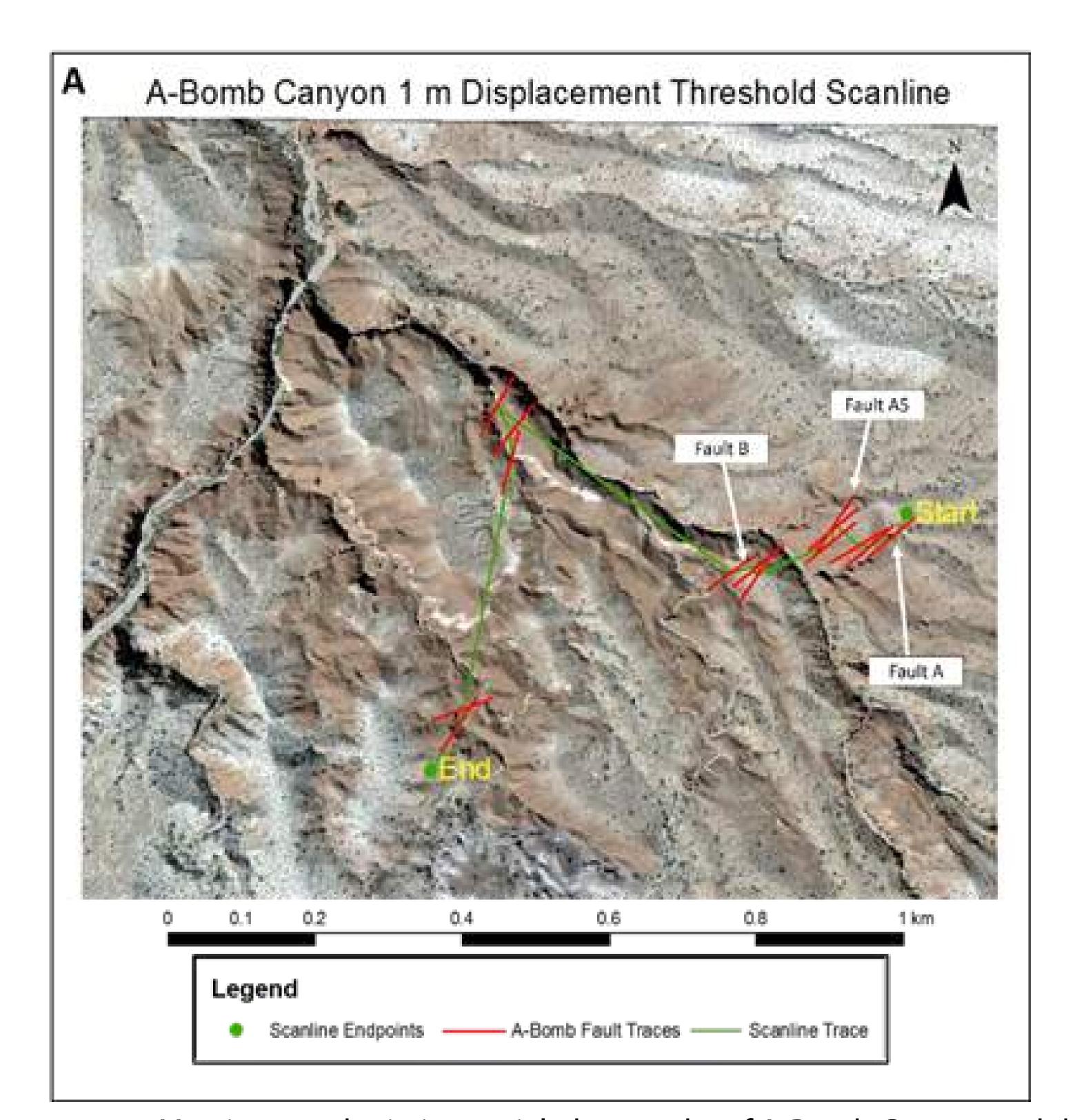


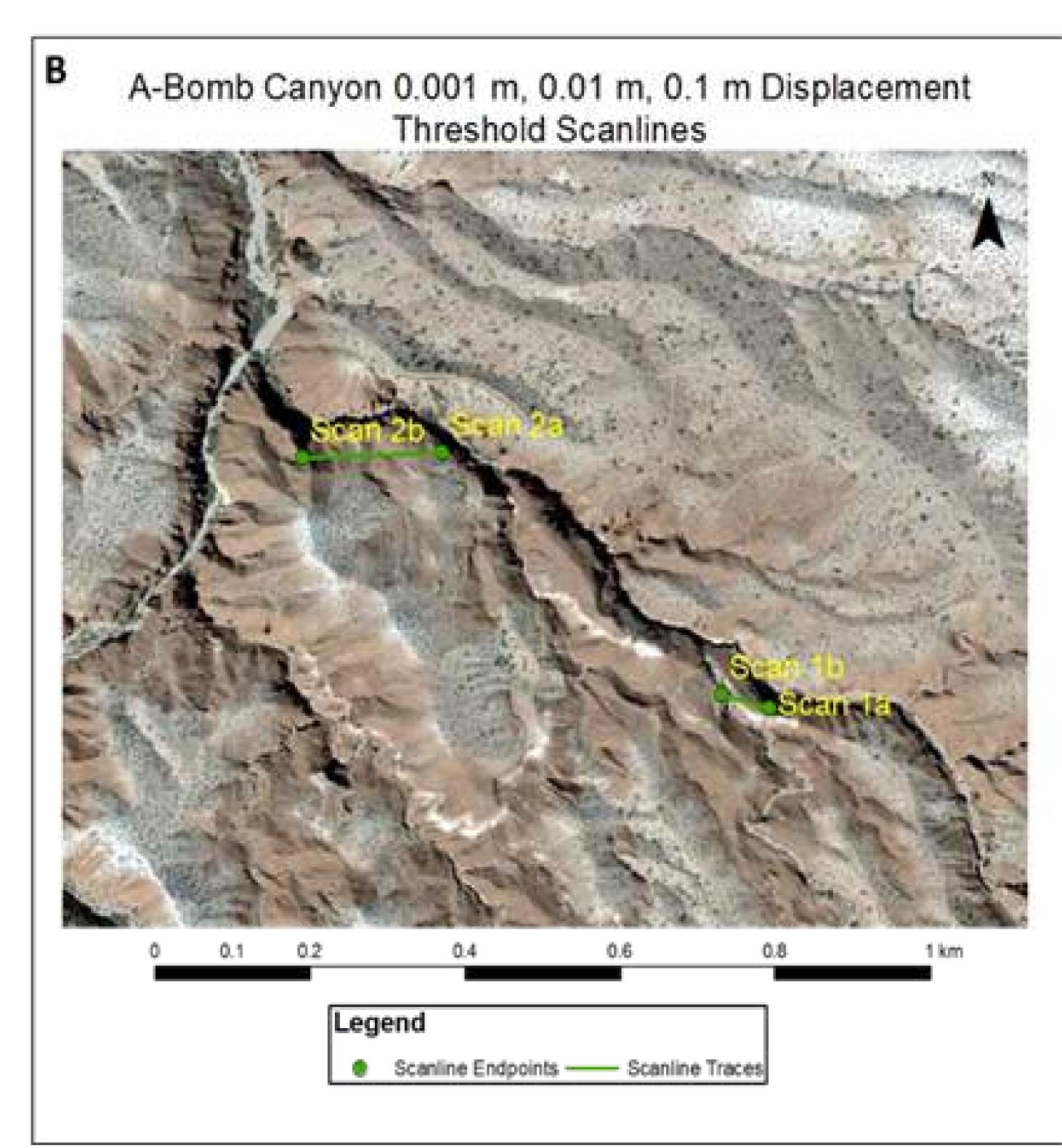
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Scanline Locations and Paths





Map images depicting aerial photgraphy of A-Bomb Canyon and the scanline pathways utilized for data collection on Normal Faults



Field photograph of the inside of A-Bomb Canyon to illustrate the exposure of the Chapin Wash. Normal fault data was collected on scanlines along the canyon on this exposure.



Field photograph of Fault B, one of the > 1 meter displacement faults found along the longer scanline pathway.

Spatial Arrangement Conclusions:

 Normalized Correlation Count analysis indicates that the largest displacement faults exhibit a regular spacing of approximately 20 meters

-This conclusion is supported by the intensity plot analysis as well as Fourier Analysis

-Normalized Correlation Count analysis indicates that faults with displacement thresholds of 0.001 m, 0.01 m and 0.1 m all exhibit inherited or imposed clustering

-This conclusion is also supported by both the intensity and Fourier analysis

- Cluster widths for the 0.001 m displacment threshold faults is approximately 1 meter
- Cluster width for the 0.01 m displacement threshold faults is approximately 14 meters
- Cluster widths for the 0.1 m displacement threshold faults is approximately 20 meters.
- In every case of normal faults in A-Bomb Canyon it was determined that the faults exhibit non-randomness on one length scale or another

-The display on non-randomness allows for the conclusion that the faults are in fact arranging themselves in space dependent on some factor, most likely a mechanical property, within the Chapin Wash Formation itself as none of the faults exhibit a length greater than the approximately 120 meter thickness of the formation which they reside in.

References and Acknowledgements:

Barton, C.C., 1995. Fractal analysis of scaling and spatial clustering of fractures. In: Barton, C.C., and La Pointe, P.R. (eds.), 1995. Fractals in the Earth Sciences, Plenum Press, New York. 141-177. Gomez, L.A., and Marrett, R., in review. Spatial arrangement of fractures I — Traditional analyses. Journal of Structural Geology.

Marrett, R., Gale, J.F.W., and Gomez, L., in review. Spatial arrangement of fracture arrays III — Correlation analyses. Journal of Structural Geology.

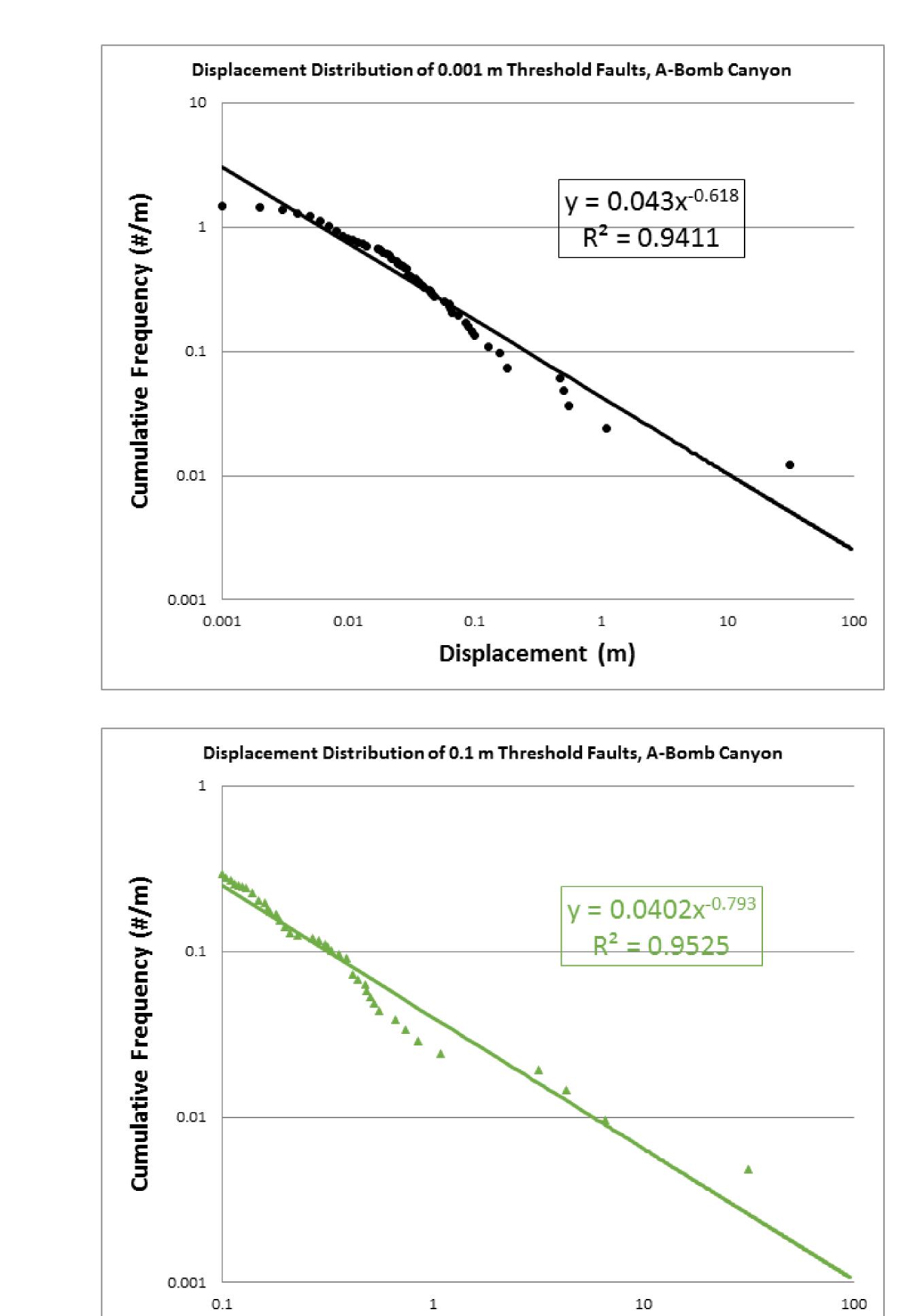
Narr, W., and Suppe, J., 1991. Joint spacing in sedimentary rocks. Journal of Structural Geology 13, 1037-1048.

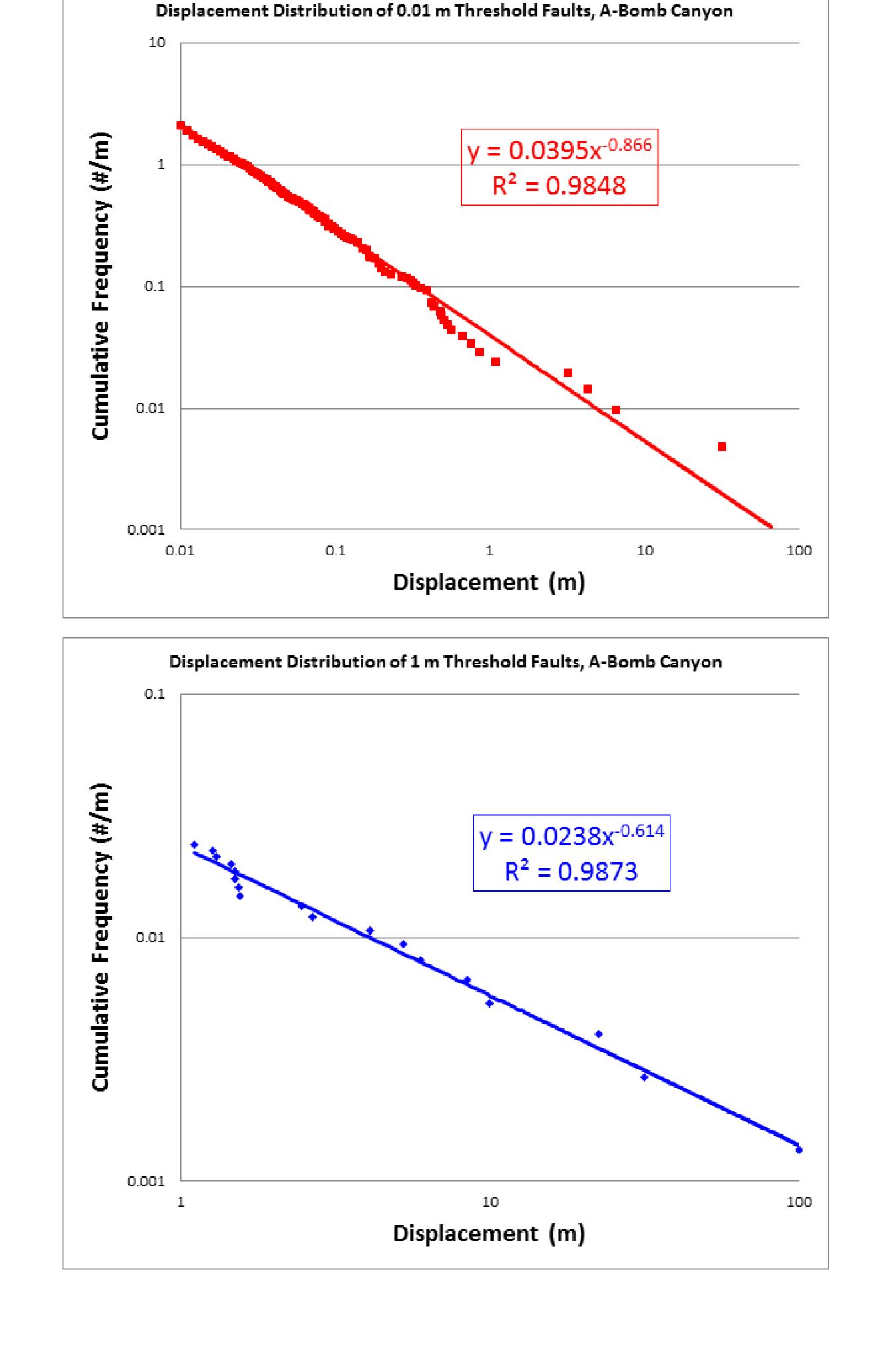
Priest, S.D., and Hudson, J.A., 1976. Discontinuity spacings in rock. Int. J. of Rock Mech. Min. Sci. and Geomech. Abstr. 13, 135-148.

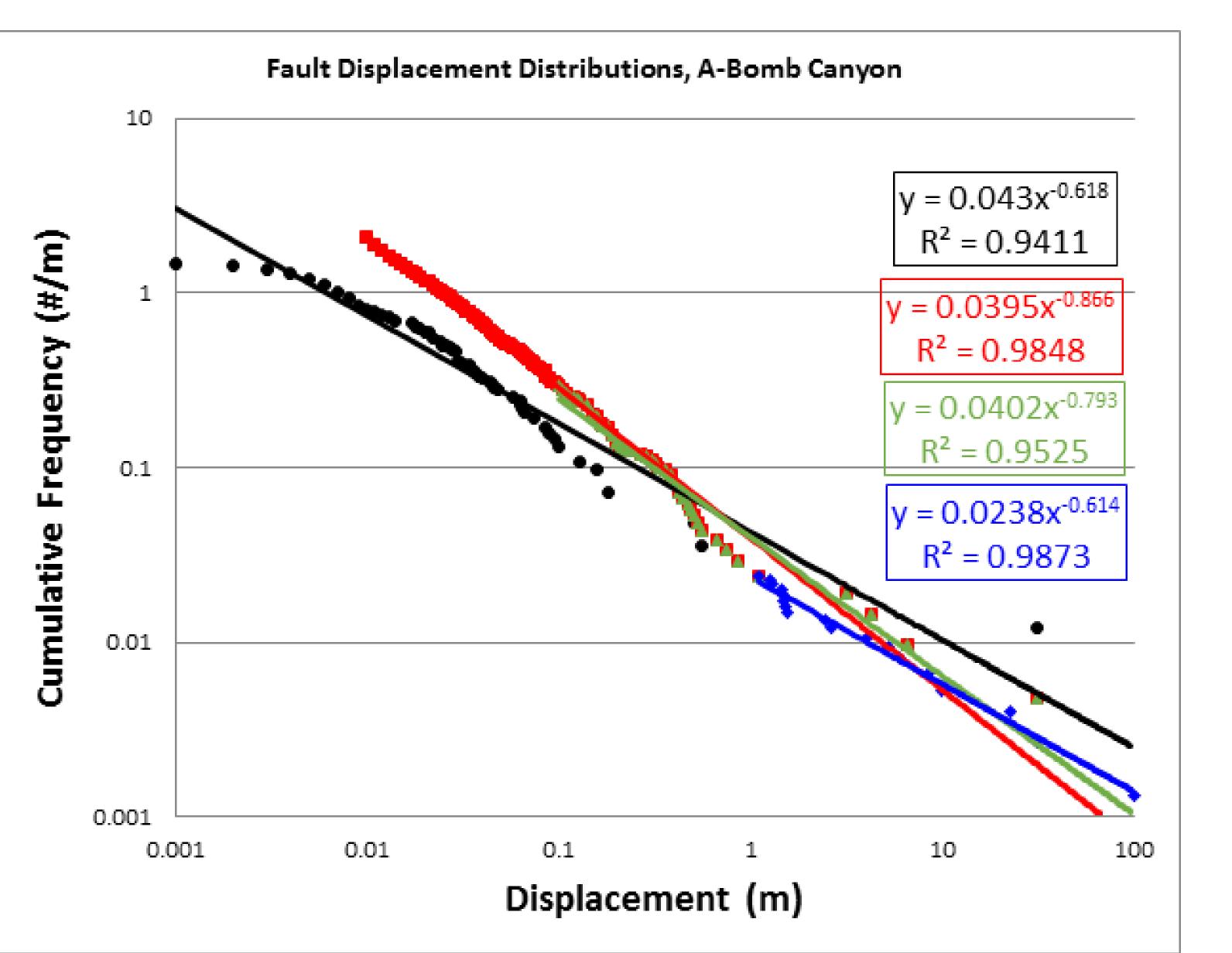
Hooker, J.N., Laubach, S.E., and Marrett, R., 2014, A universal power-law scaling exponent for fracture apertures in sandstones: Geological Society of America Bulletin, v. 126, i. 9-10, p. 1340-1362

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Size Distribution







Displacement (m)

Size Distribution Conclusions:

Data across four orders of displacement magnitude exhibit a power-law scaling
 All of the power-law scalings are characterized by negative power-law exponents

- These exponents range from -0.614 to -0.866

- The similarities among the four datasets and their size scalings allow for the determination that normal faults in A-Bomb Canyon and the surrounding area all follow a scaling described by power-laws

- The uniformity of negative power-law exponents for the normal faults in A-Bomb Canyon is very similar to that seen in orther work on fractures, most notably opening-mode fractures of all different sizes (Hooker et al., 2014) - Further work should include both a smaller and larger displacement threshold in order to understand whether the power-law scaling identified here extends to yet high or lower order of magnitude displacements