Mapping Fault Ground Rupture Hazard for Strike-slip Faults

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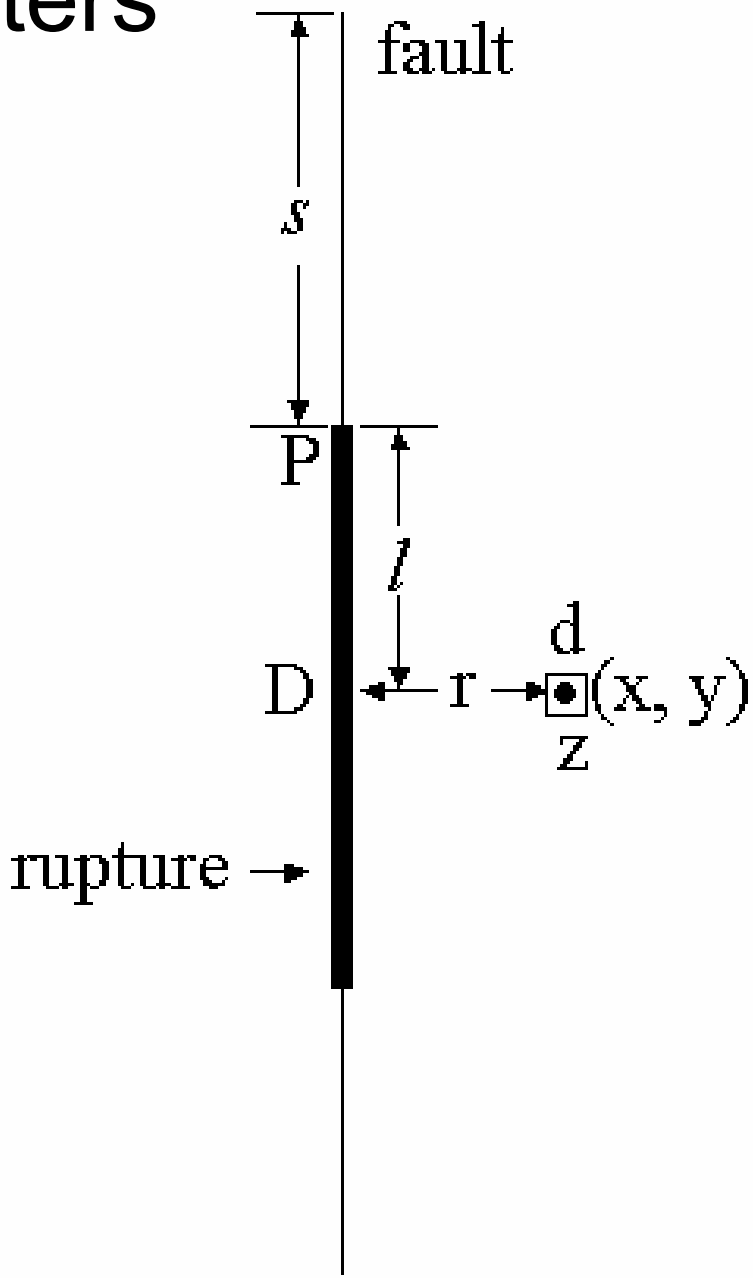
Objectives of Project

- Methodology for evaluating displacements for strike-slip faults
- On-fault displacements
- Off-fault displacements
- Evaluate on-fault displacements based on quality of mapping parameter
- Example

Definition of parameters



The off-fault surface rupture displacement is given by:

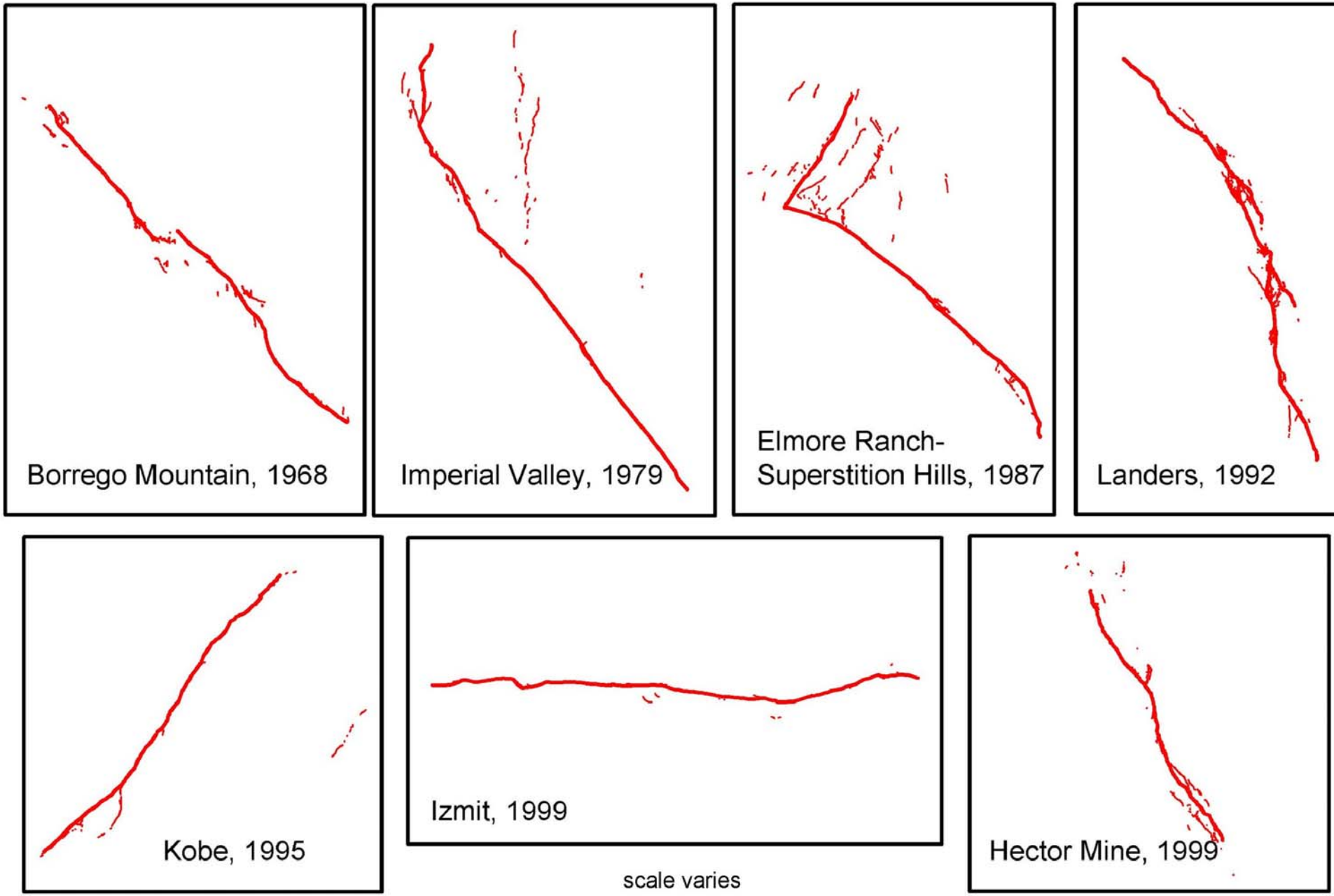
$$\lambda(d \geq d_0)_{xyz} = \alpha \int_m \int_s \int_D P[sr_{on-fault} \neq 0 \mid m] f_{M,S}(m,s) P[sr_{off-fault} \neq 0 \mid z, r(s), m, sr_{on-fault} \neq 0] \times$$

$$f_D(D_0, D_{ave}(m), l(s)) P[d \geq d_0 \mid D_0, m, r(s), z, sr_{on-fault} \neq 0, sr_{off-fault} \neq 0] dDdsdm$$

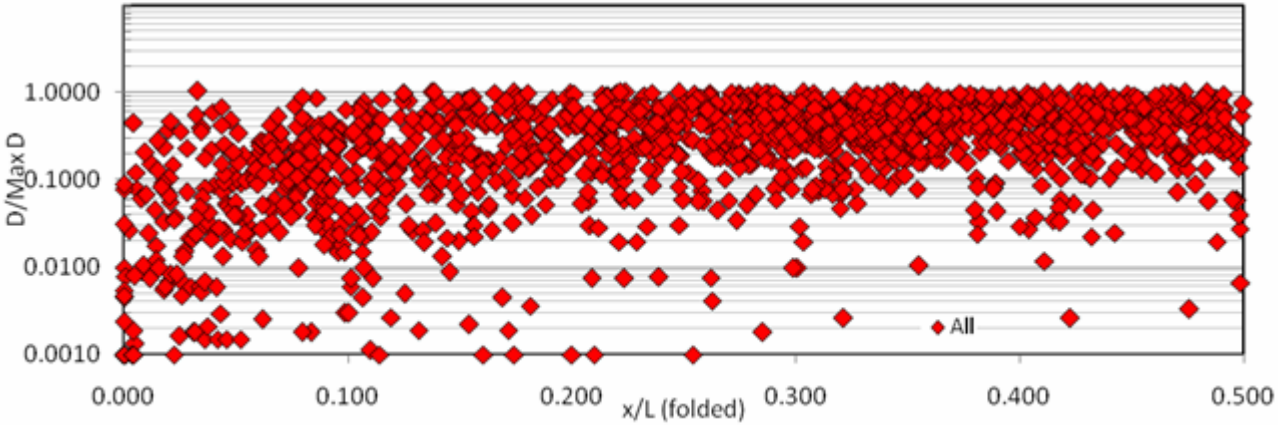
The on-fault surface rupture displacement for a given mapping quality is given by:

$$\lambda(D \geq D_0)_{xy} = \int_m \alpha_m P[sr_{on-fault} \neq 0 \mid m] f_M(m) \int_r f_R(r,s,l) \times$$

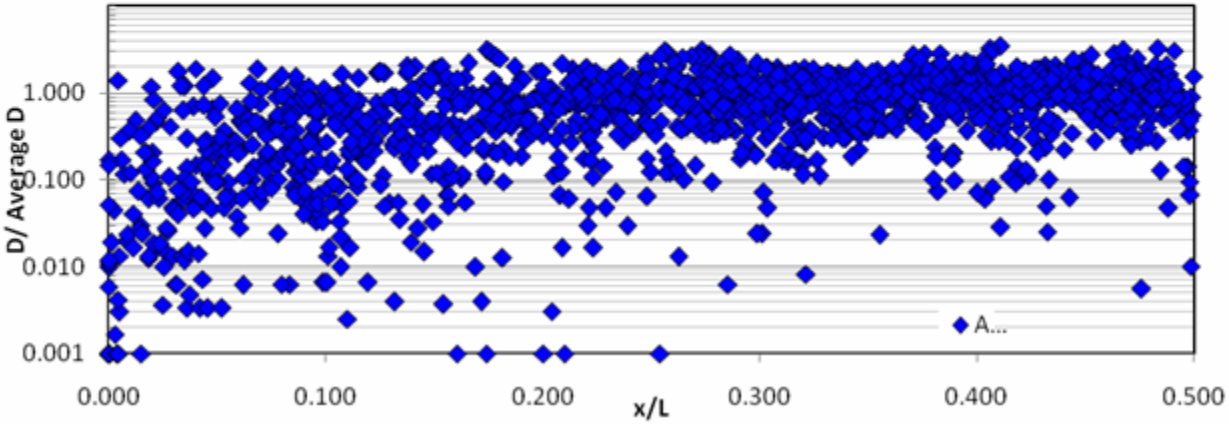
$$\int_D P[D \geq D_0 \mid sr_{on-fault} \neq 0, m, r, s, l, quality] dDdrdm$$


Borrego Mountain, 1968
Imperial Valley, 1979
Elmore Ranch-
Superstition Hills, 1987
Landers, 1992
Kobe, 1995
Izmit, 1999
Hector Mine, 1999
scale varies

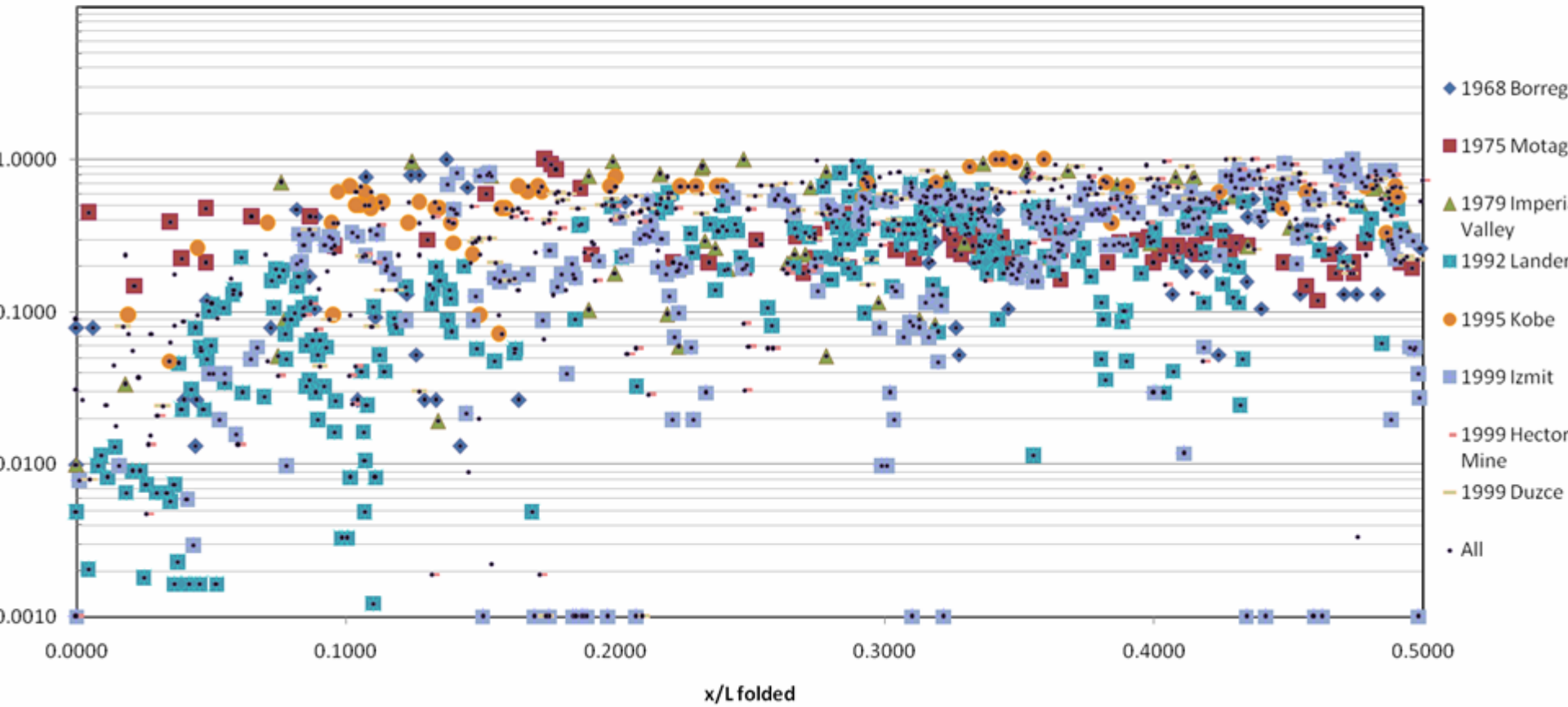
Normalized to Maximum Displacement: This Compilation and Wesnousky earthquakes



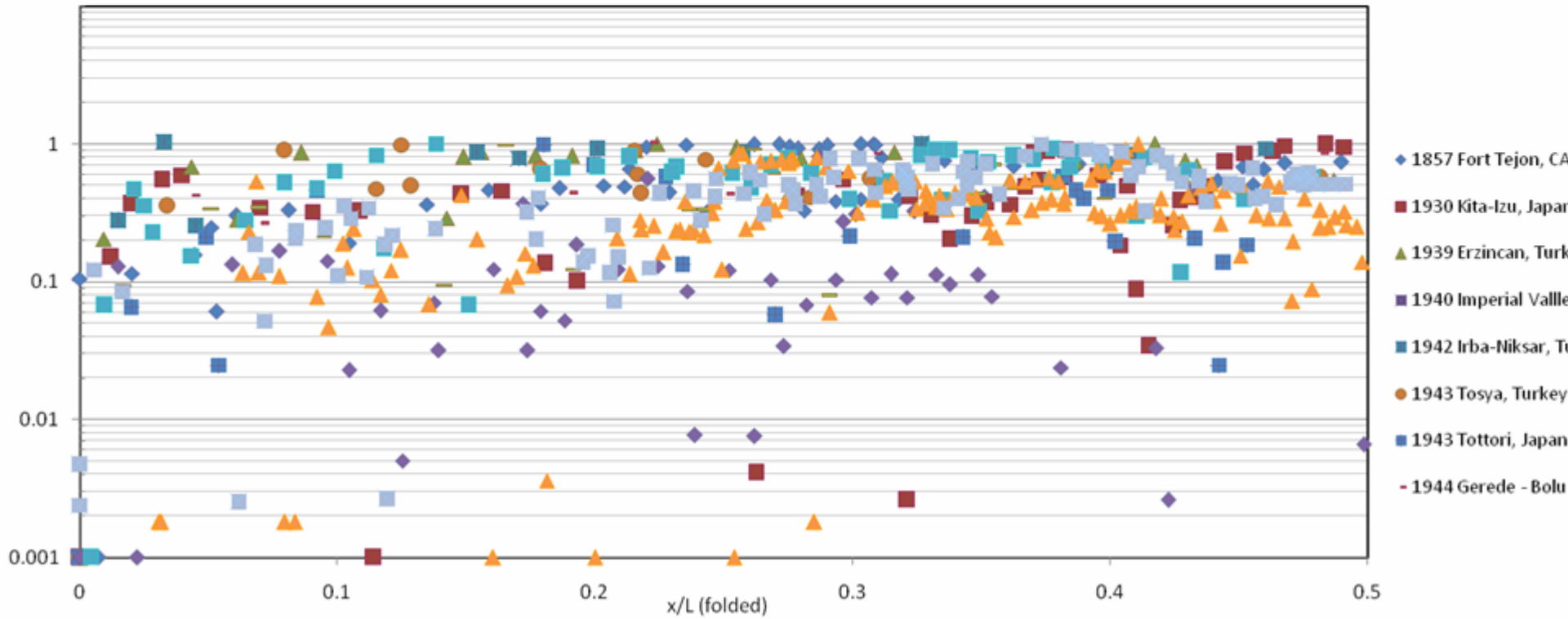
Normalized to Average Displacement: This Compilation and Wesnousky (2008) earthquakes



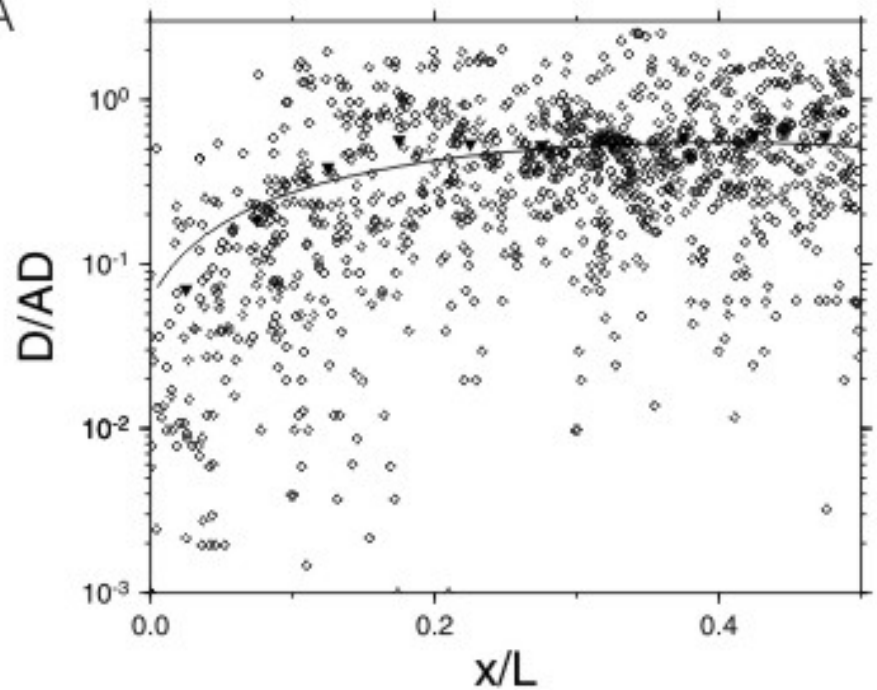
This Study:
Normalized to Maximum Displacement



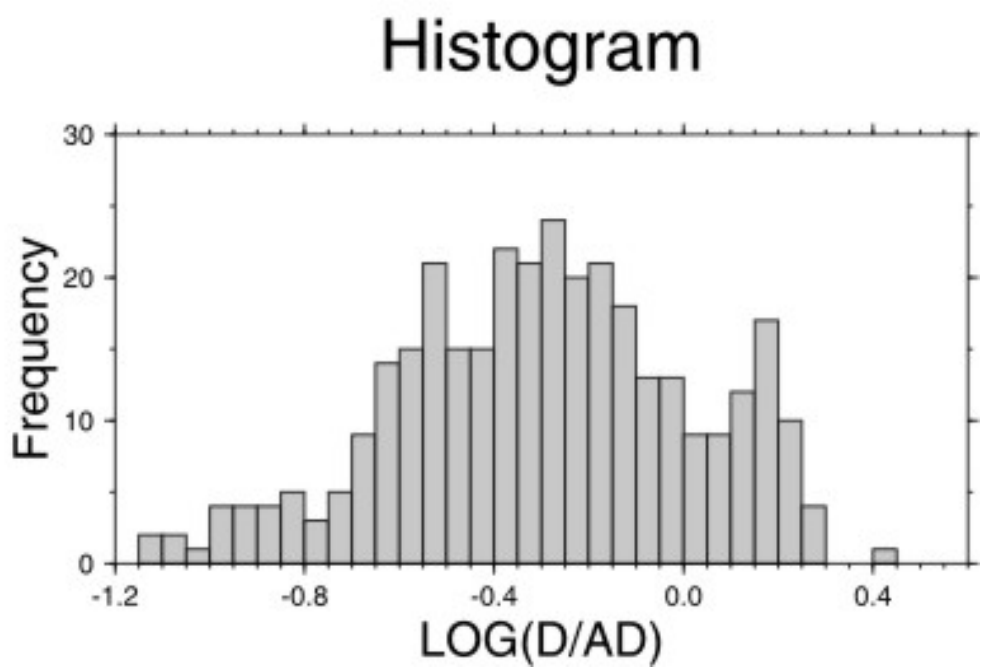
Wesnousky (2008) Earthquakes: Normalized to Maximum Displacement

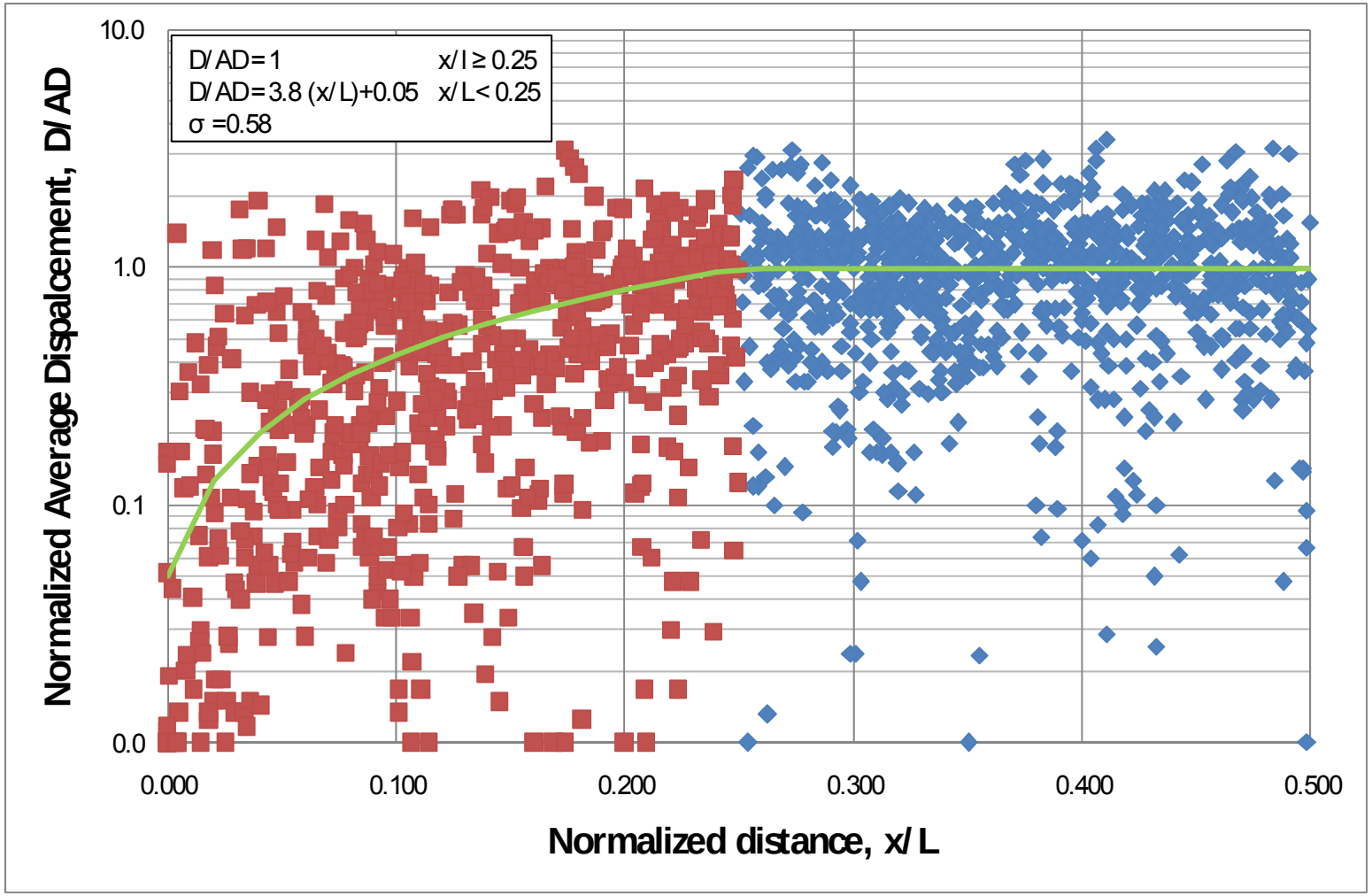


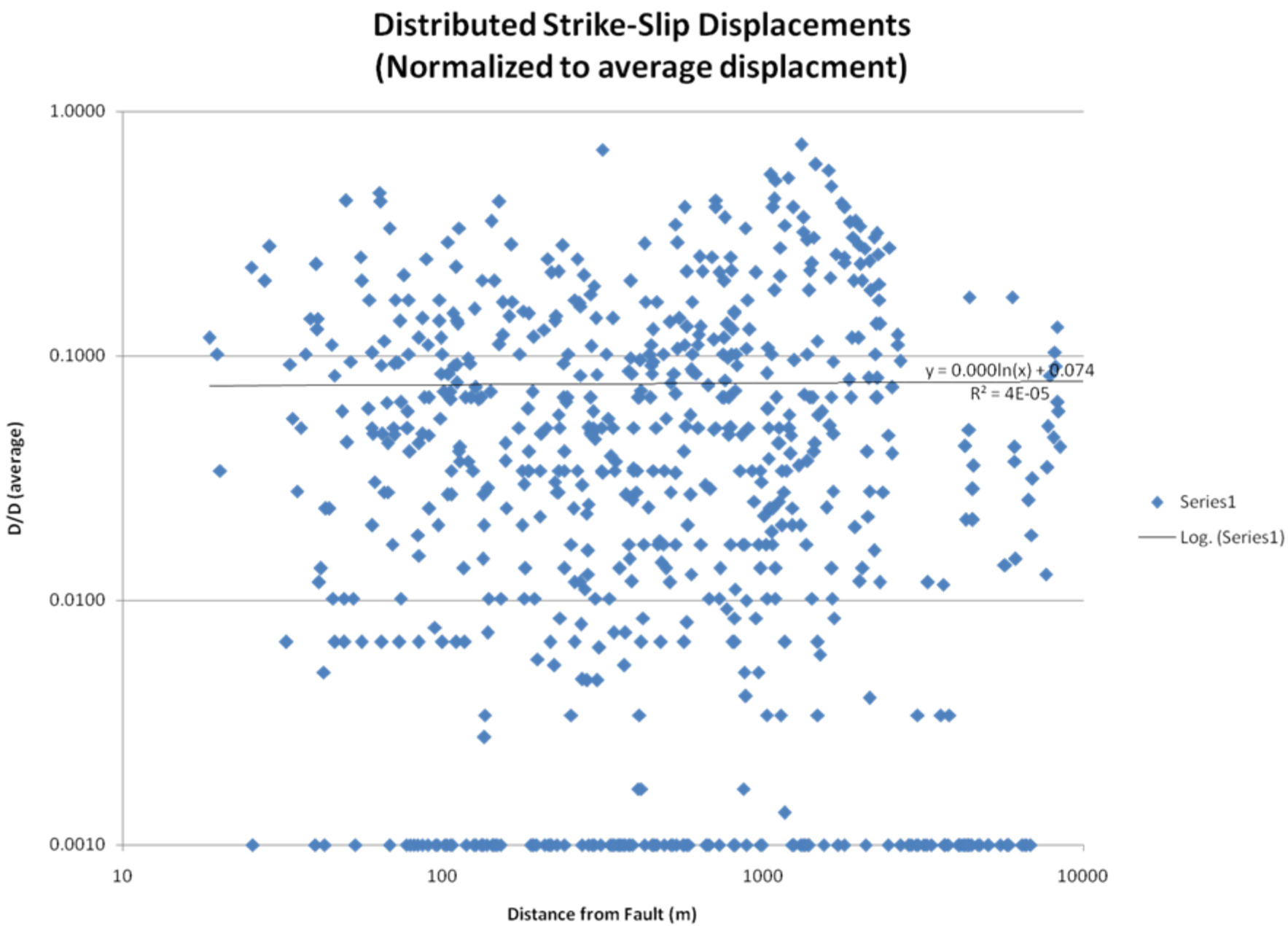
A

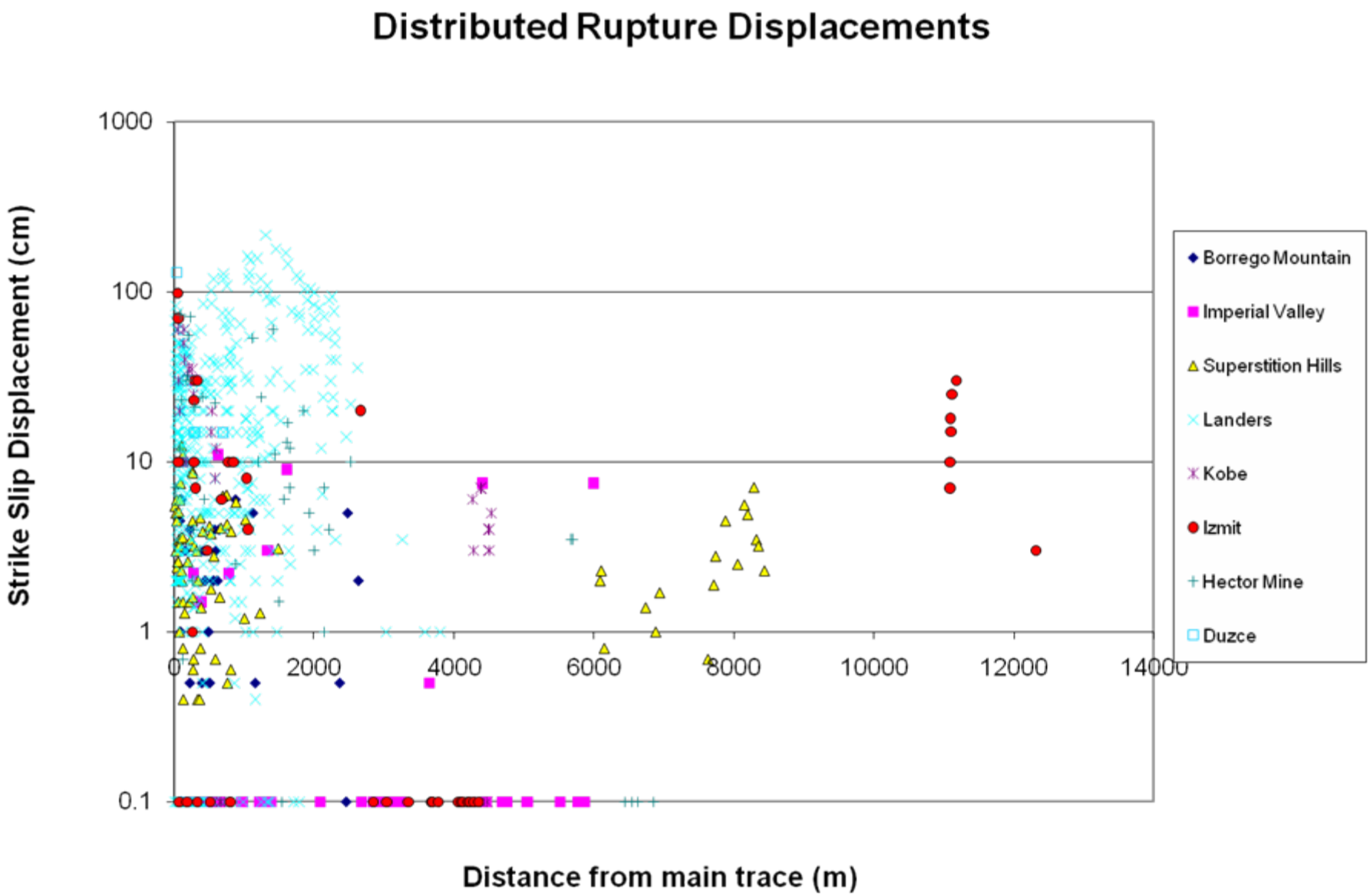

D/AD
10^0
10^{-1}
10^{-2}
10^{-3}
0.0
0.2
0.4
x/L

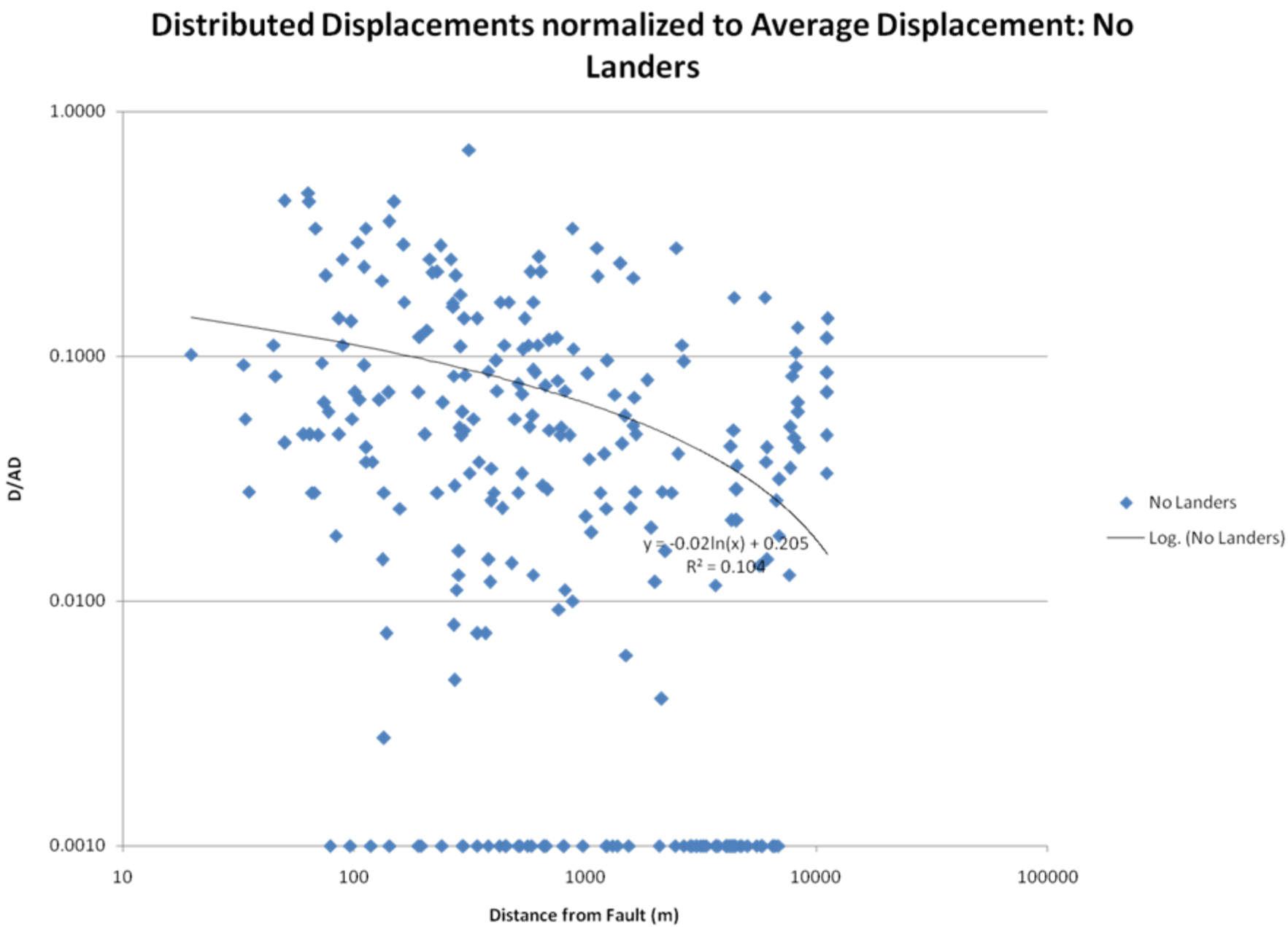
B

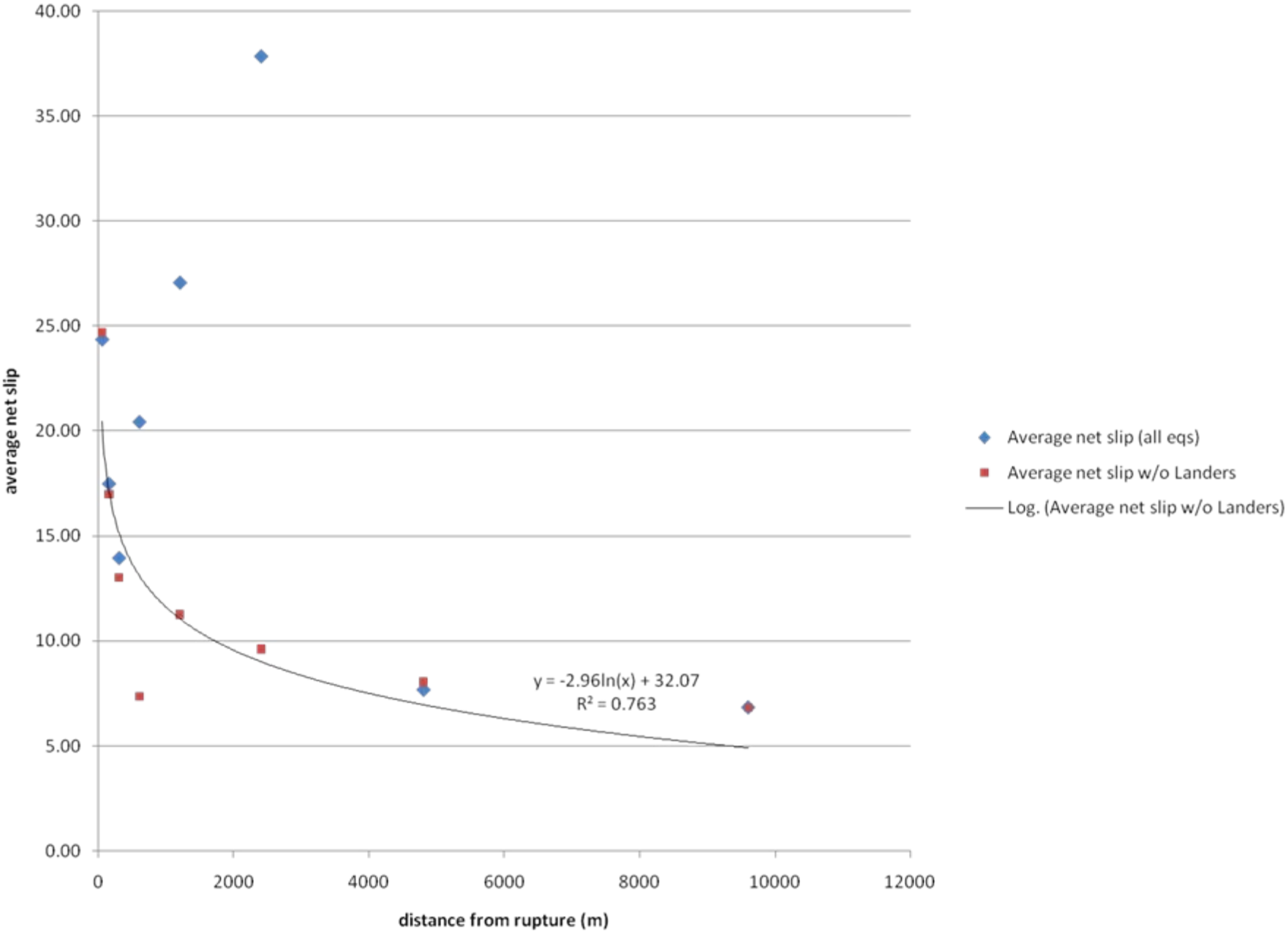

Histogram
Frequency
30
20
10
0
-1.2
-0.8
-0.4
0.0
0.4
LOG(D/AD)

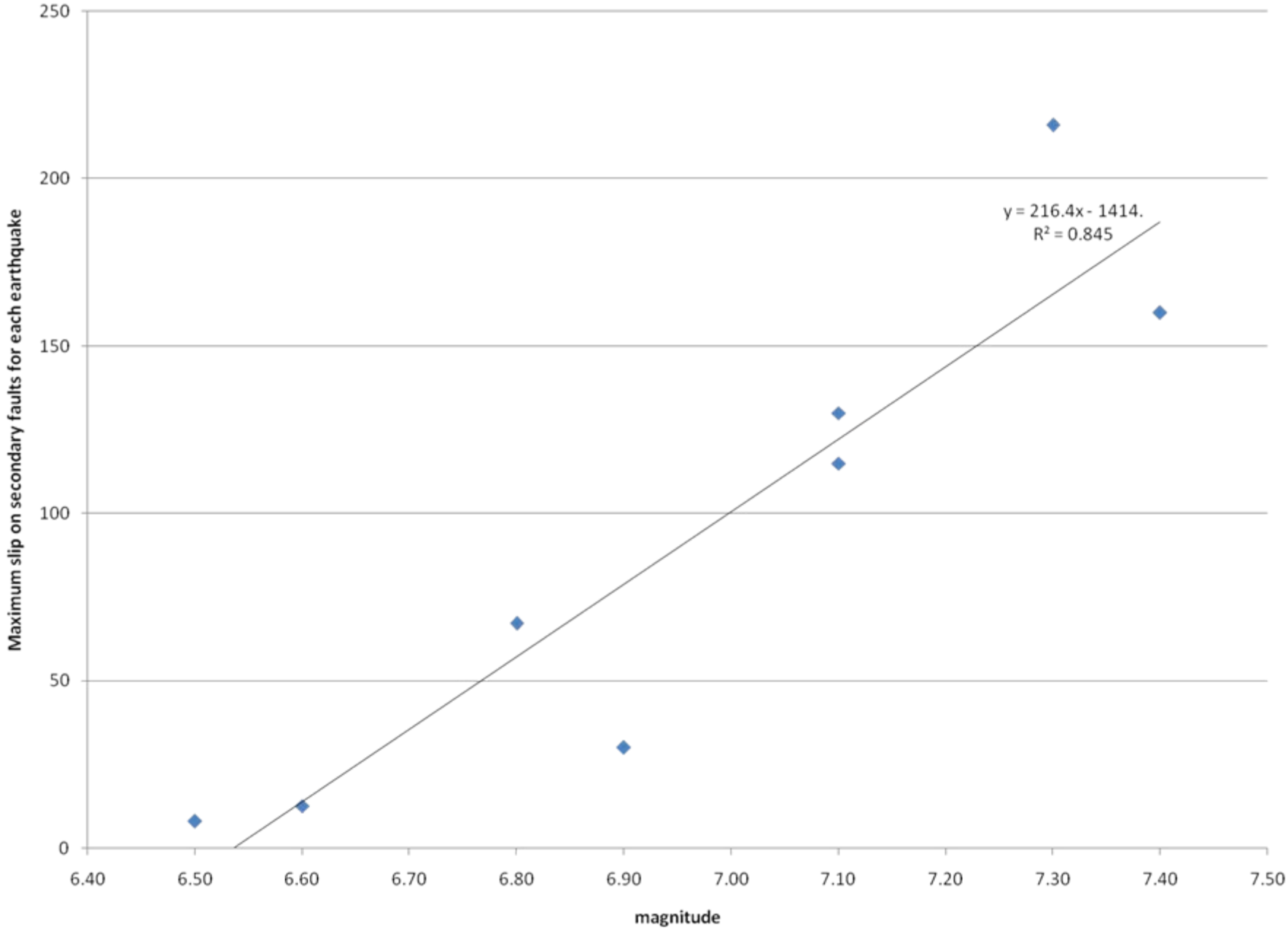

D/AD=1 x/l ≥ 0.25
D/AD=3.8 (x/L)+0.05 x/L< 0.25
σ =0.58
10.0
1.0
0.1
0.0
0.000
0.100
0.200
0.300
0.400
0.500
Normalized Average Displacement, D/AD
Normalized distance, x/L

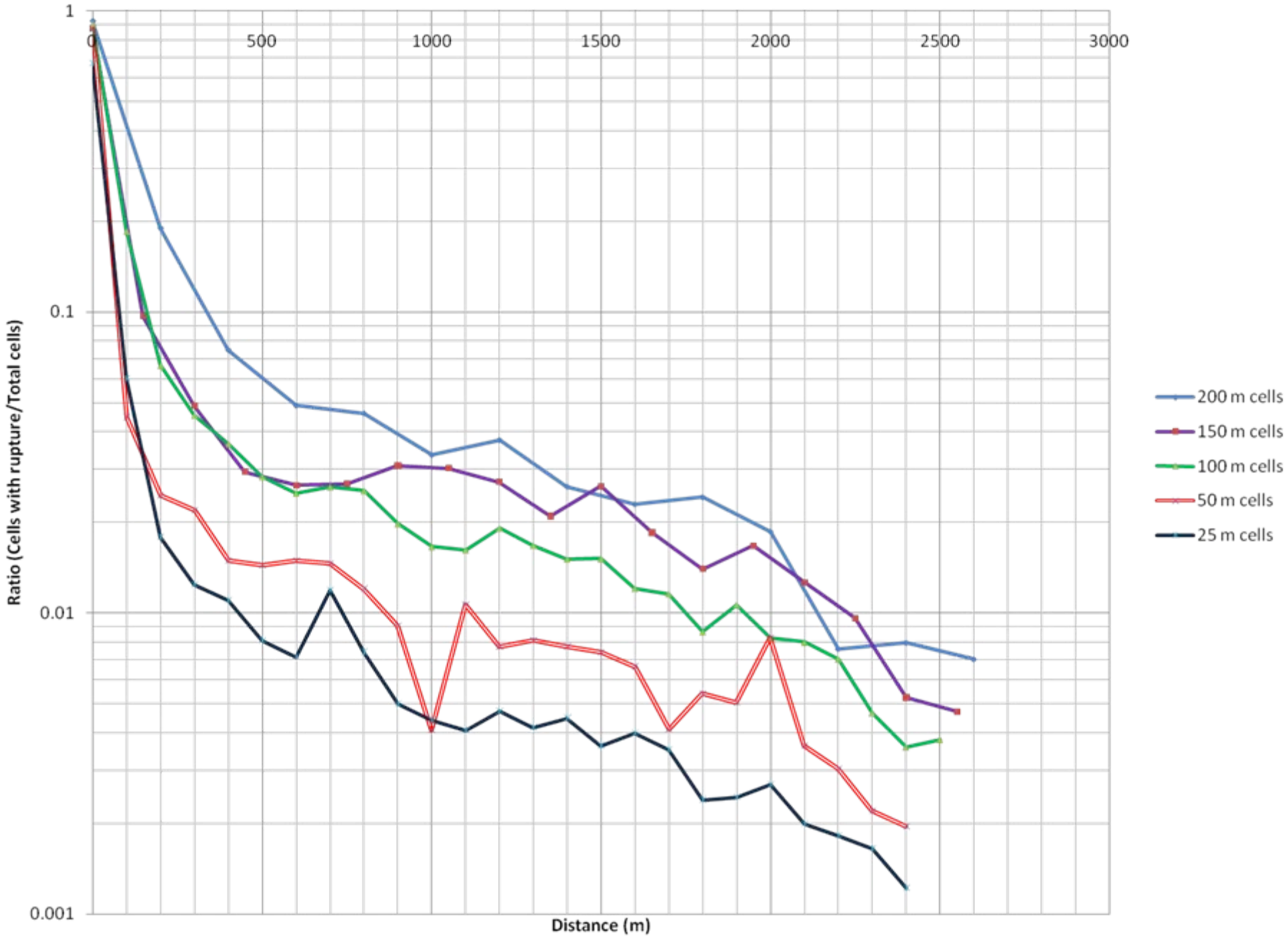

Distributed Strike-Slip Displacements
(Normalized to average displacment)
1.0000
0.1000
0.0100
0.0010
D/D (average)
10
100
1000
10000
Distance from Fault (m)
y = 0.000ln(x) + 0.074
R² = 4E-05
Series1
Log. (Series1)


Distributed Rupture Displacements
Strike Slip Displacement (cm)
1000
100
10
1
0.1
0
2000
4000
6000
8000
10000
12000
14000
Distance from main trace (m)
Borrego Mountain
Imperial Valley
Superstition Hills
Landers
Kobe
Izmit
Hector Mine
Duzce


Distributed Displacements normalized to Average Displacement: No Landers
1.0000
0.1000
0.0100
0.0010
D/AD
10
100
1000
10000
100000
Distance from Fault (m)
y = -0.02ln(x) + 0.205
R² = 0.104
No Landers
Log. (No Landers)

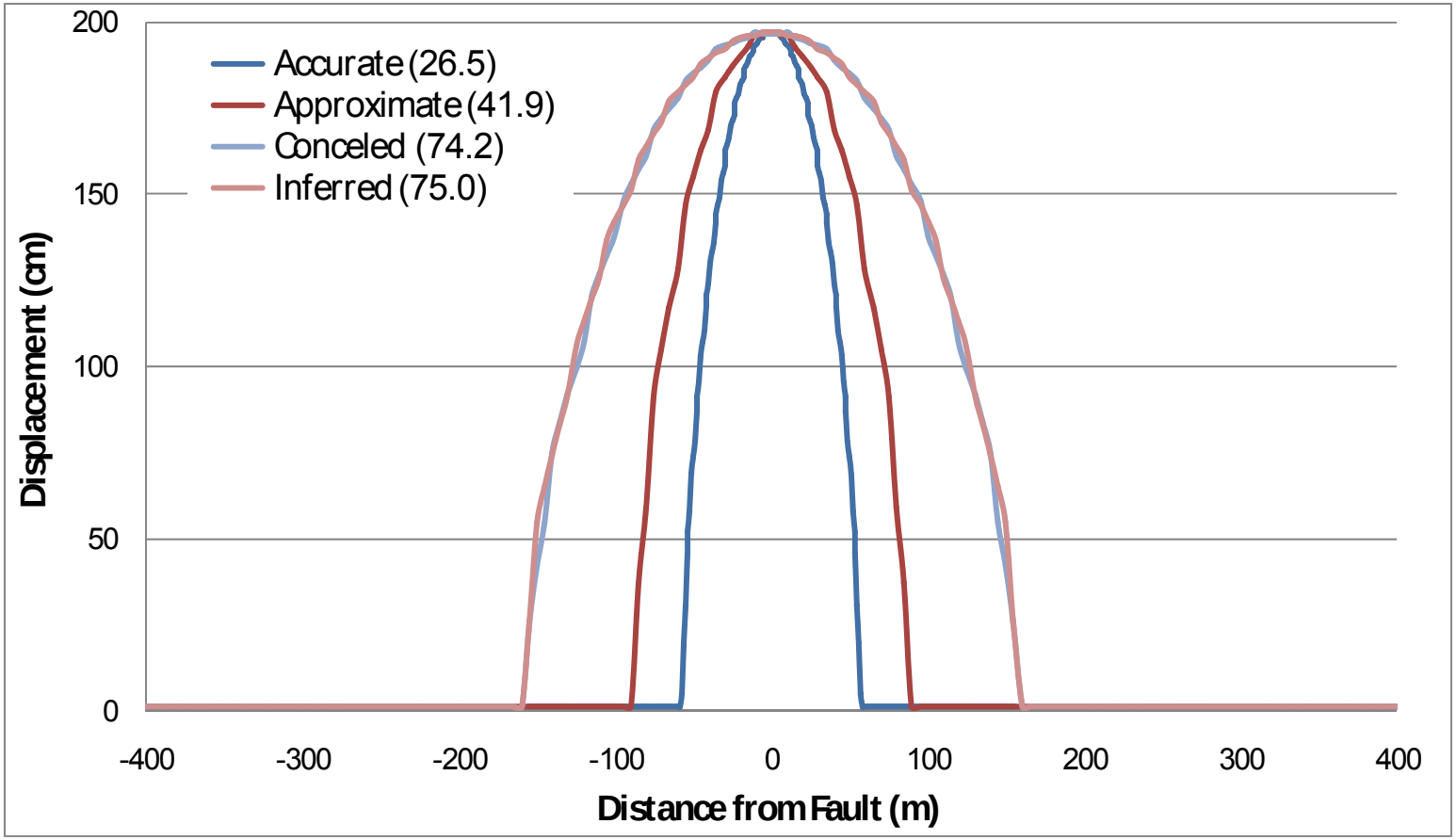

40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
average net slip
0
2000
4000
6000
8000
10000
12000
distance from rupture (m)
y = -2.96ln(x) + 32.07
R² = 0.763
Average net slip (all eqs)
Average net slip w/o Landers
Log. (Average net slip w/o Landers)

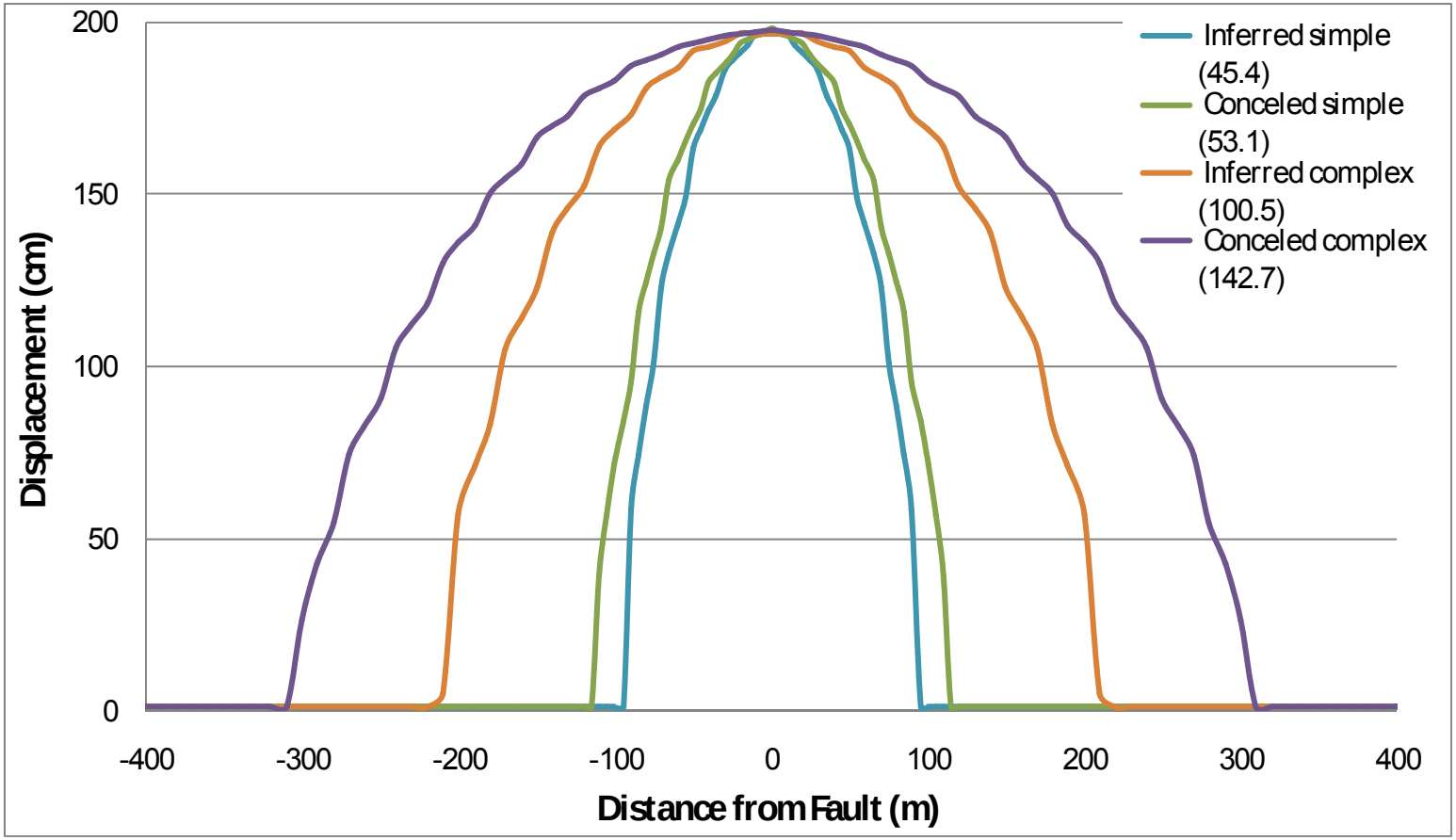

y = 216.4x - 1414.
R² = 0.845
Maximum slip on secondary faults for each earthquake
magnitude
250
200
150
100
50
0
6.40
6.50
6.60
6.70
6.80
6.90
7.00
7.10
7.20
7.30
7.40
7.50

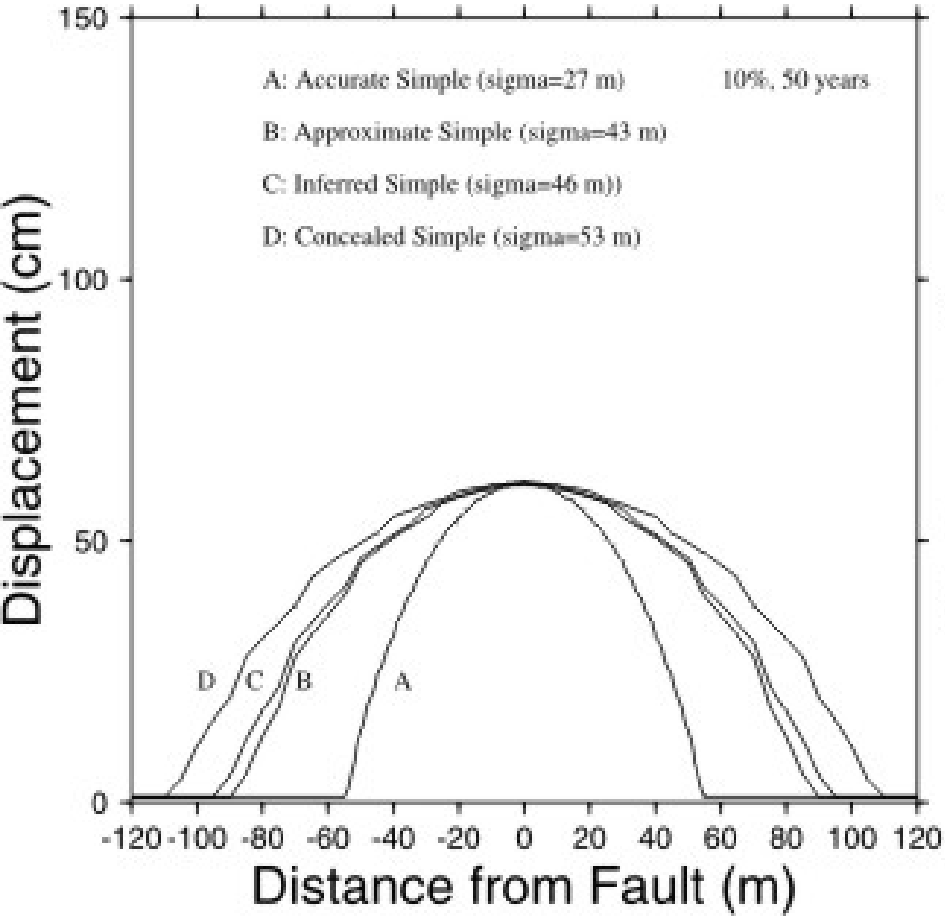

1
0.1
0.01
0.001
0
500
1000
1500
2000
2500
3000
Ratio (Cells with rupture/Total cells)
Distance (m)
200 m cells
150 m cells
100 m cells
50 m cells
25 m cells

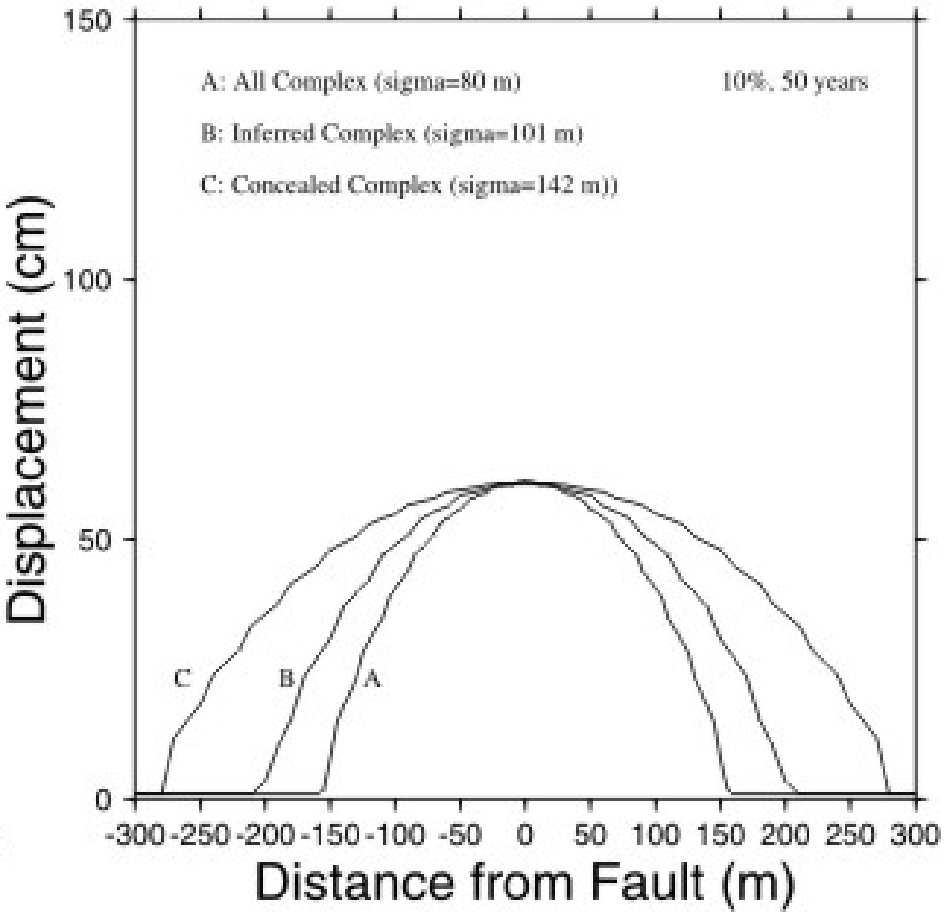
Mapping accuracy

- Applied to primary trace
- May include both epistemic uncertainty (how well mapped) and alleatory variability (future ruptures may not be located along identical traces).
- Use A-P zone terminology


Accurate (26.5)
Approximate (41.9)
Conceled (74.2)
Inferred (75.0)
Displacement (cm)
200
150
100
50
0
-400
-300
-200
-100
0
100
200
300
400
Distance from Fault (m)


200
150
100
50
0
Displacement (cm)
-400
-300
-200
-100
0
100
200
300
400
Distance from Fault (m)
Inferred simple (45.4)
Conceled simple (53.1)
Inferred complex (100.5)
Conceled complex (142.7)


A: Accurate Simple (sigma=27 m)
10%, 50 years
B: Approximate Simple (sigma=43 m)
C: Inferred Simple (sigma=46 m))
D: Concealed Simple (sigma=53 m)
Displacement (cm)
Distance from Fault (m)
D
C
B
A
150
100
50
0
-120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120


A: All Complex (sigma=80 m)
10%, 50 years
B: Inferred Complex (sigma=101 m)
C: Concealed Complex (sigma=142 m))
Displacement (cm)
Distance from Fault (m)
C
B
A
150
100
50
0
-300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300

$$\lambda(d \geq d_0)_{xyz} =$$

$$\alpha \int_m f_M(m) \int_s f_S(s) \; P[sr \neq 0 \mid m]$$

$$\times \int_r f_R(r) \; f_z(z, r, m)$$

$$\times \int_D f_D(D(D_{ave}, l)) P[d \geq d_0 \mid D(D_{ave}, l), d \neq 0]$$

$$\times \; dDdrdsdm$$