November 4, 2004
FINAL REPORT

1-D ROCK MOTION SIMULATIONS

Project 1L08

A PEARL REPORT

to

PG&E/CEC/Caltrans

by

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1. INTRODUCTION

The objective of this project was to simulate motions for a suite of earthquake magnitudes, rupture mechanisms, and site locations.

The simulation procedure implemented here is termed the stochastic finite fault model (Silva et al., 1997) in which near surface (top 100 to 1,000 ft) materials are considered in detail through an equivalent-linear formulation.

2. STOCHASTIC FINITE-FAULT MODEL

The stochastic finite-fault model implemented here is quite simple in concept, using a single-corner-frequency omega-square source spectrum (**M** = 5.0) for each subfault. Large earthquakes are simulated by simply delaying and summing contributions from the **M** 5 subfaults. The process is discussed in detail in Appendix A. The model is simple, includes a frequency domain random vibration theory equivalent-linear site response implemented for both rock and soil sites (Silva et al., 1997). The model, including site effects, has recently been validated at about 500 sites for 15 earthquakes (**M** 5.2 to 7.4) over fault distances ranging from 1 km to 470 km (Silva et al., 1997) and for subduction zone earthquakes for **M** up to 8.1. In general, the model is unbiased over the frequency range of recorded motions (spectral acceleration averaging from about 0.3 to 100 Hz).

3. EARTHQUAKES, RUPTURE MECHANISMS, AND SITES

Tables 1 and 2 list the PEER specified magnitude, rupture lengths, and rupture areas. Considering both the strike-slip and reverse-slip mechanisms, 22 sources are required and approximately 150 site locations for a total of 3,300 simulations

4. MODELING RESULTS

Summaries of the simulations are shown in Figure Sets 1 and 2 for strike-slip and reverse-slip mechanisms respectively. For each mechanism (Tables 1 and 2) results for each earthquake (magnitude and rupture area) in terms of medium (of 30 realizations) peak values verses distance as well as median response spectra (5% damped) at rupture distances of 1, 5, 10, 100, 140, and 200 km.

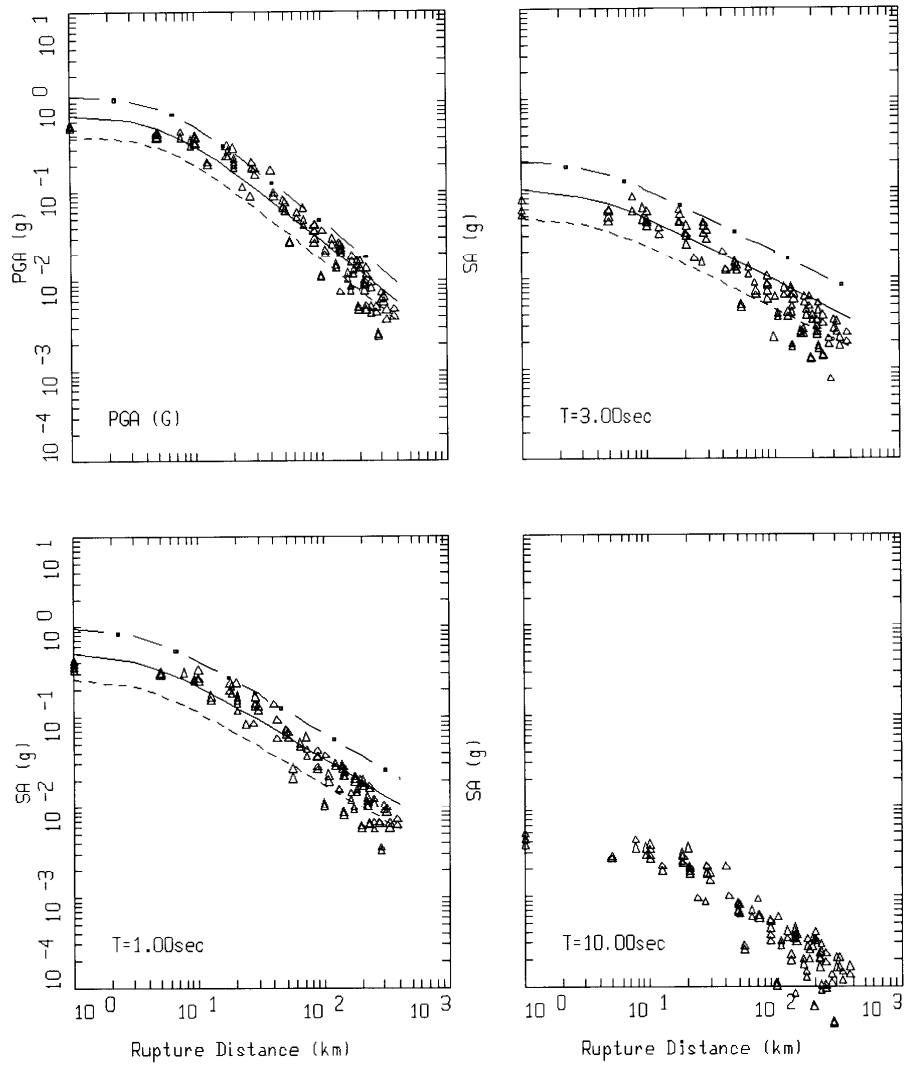
5. REFERENCES

Silva, W.J., N. Abrahamson, G. Toro and C. Costantino. (1997). "Description and validation of the stochastic ground motion model." Report Submitted to Brookhaven National Laboratory, Associated Universities, Inc. Upton, New York 11973, Contract No. 770573.

Table 1 **Rupture Dimensions for Strike-Slip Simulations**						
Event Name	Mag.	Area (km ^ 2)	W (km)	L (km)	Dip	Top of Rupture (km)
SA	6.5	325	13	25	90	0
SB	6.5	480	15	32	90	0
SC	6.5	210	10	21	90	0
SD	7.0	1005	15	67	90	0
SE	7.5	3150	15	210	90	0
SF	7.5	4800	15	320	90	0
SG	7.5	2100	15	140	90	0
SH	7.8	6300	15	420	90	0
SI	7.8	3525	15	235	90	0
SJ	8.2	7050	15	470	90	0

Table 2 **Rupture Dimensions for Reverse-Slip Simuilations**						
Event Name	Mag.	Area (km ^ 2)	W (km)	L (km)	Dip	Top of Rupture (km)
RA	6.5	324	18	18	30	5
RB	6.5	324	18	18	45	0
RC	6.5	324	18	18	45	5
RD	6.5	324	18	18	45	10
RE	6.5	324	18	18	60	5
RF	7.0	1024	32	32	30	0
RG	7.0	1008	28	36	45	0
RH	7.0	1008	21	48	45	5
RI	7.0	989	23	43	60	0
RJ	7.5	3160	40	79	30	0
RK	7.5	3164	28	113	45	0
RL	7.8	6320	40	158	30	0

Figure Set 1. Strike-Slip Mechanisms



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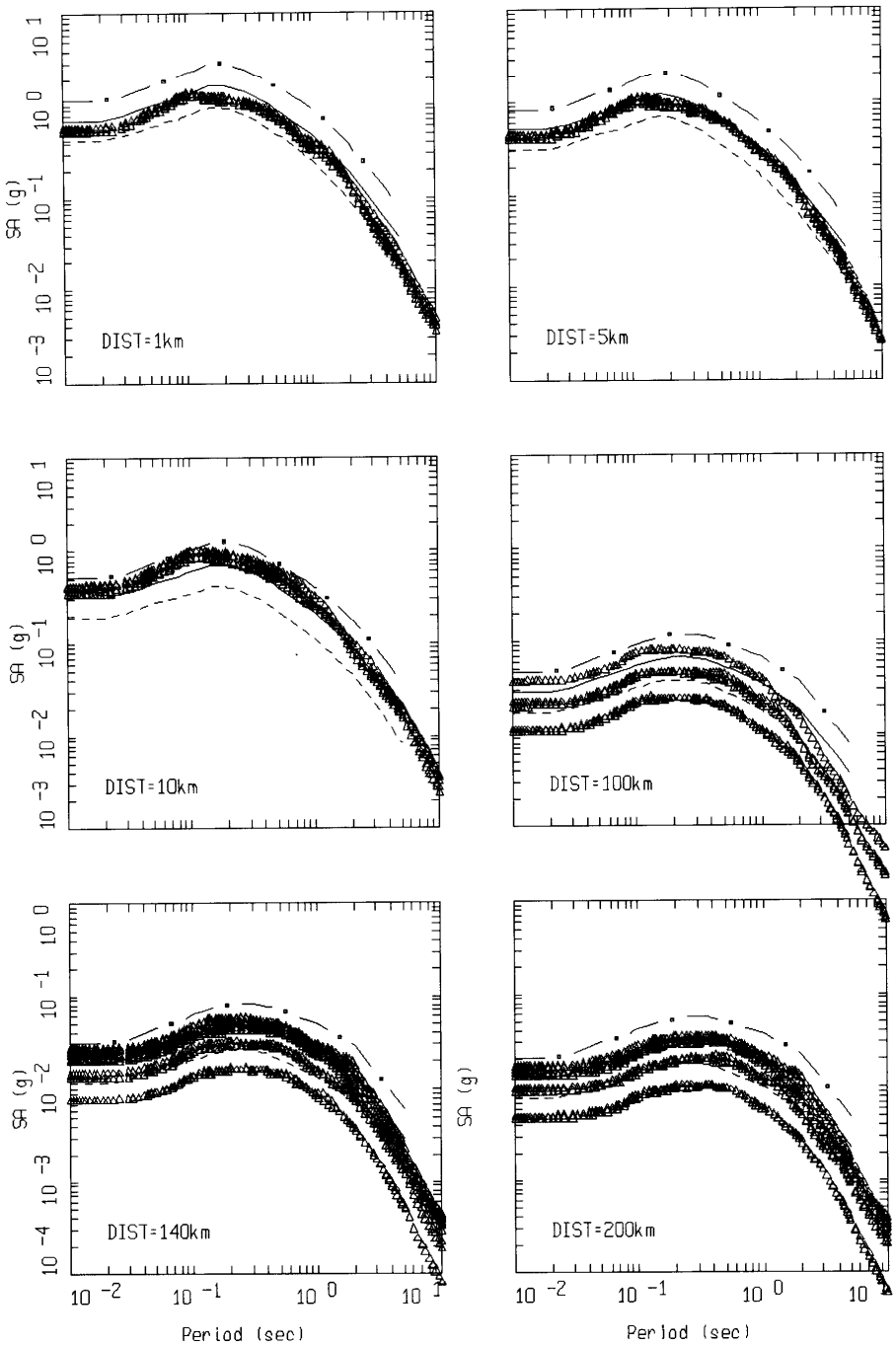
△ △	PEER SIMULATIONS, CASE SD, T=1.00 SEC
— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: SA
M=6.5, L=25km, W=13km, DIP=90, DEEP SLIP



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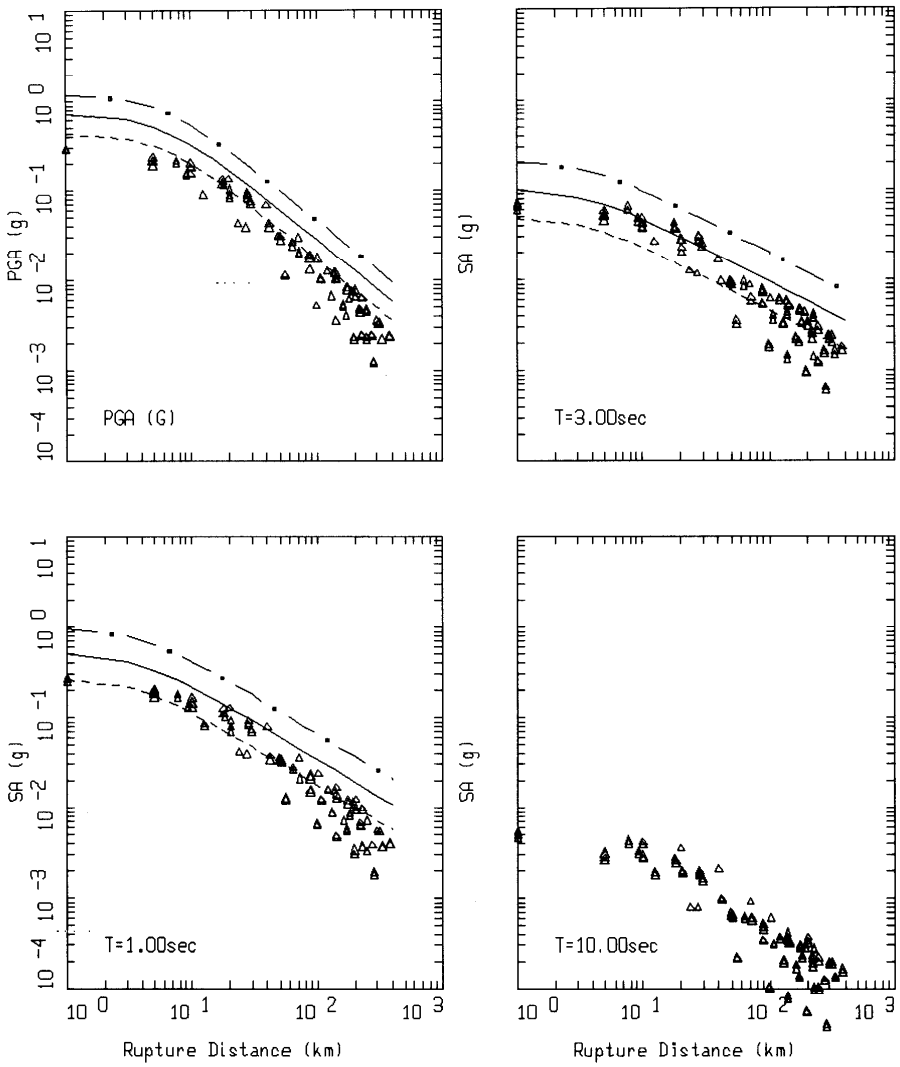

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- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

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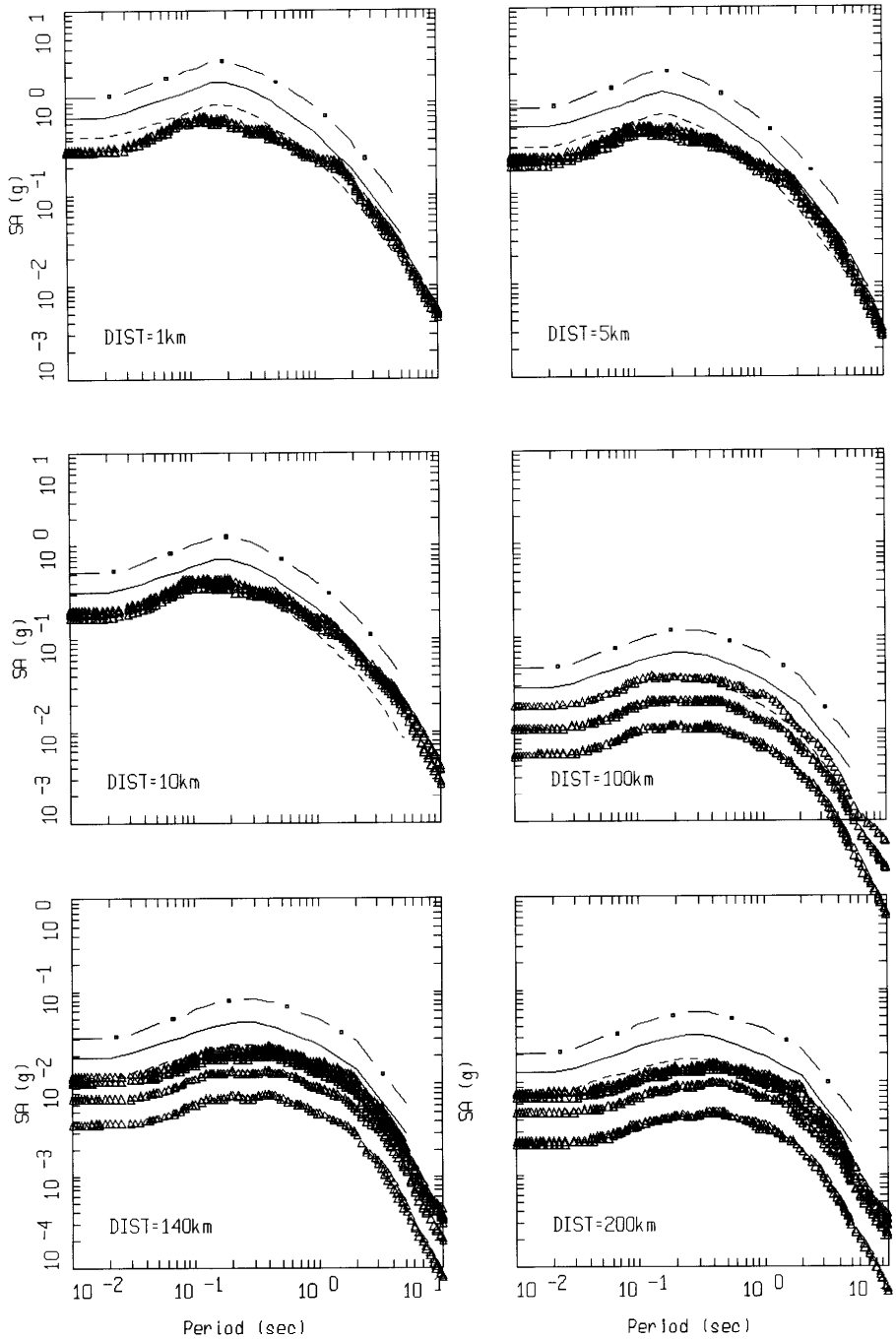

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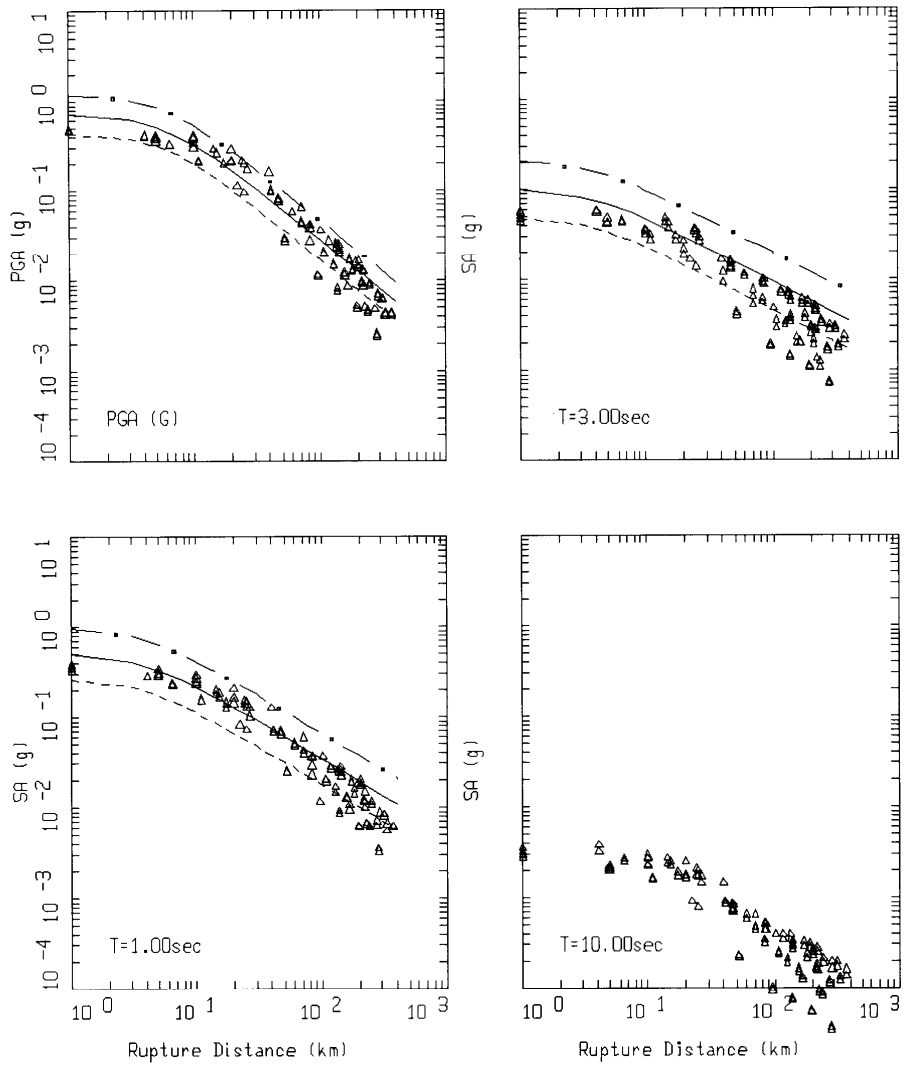

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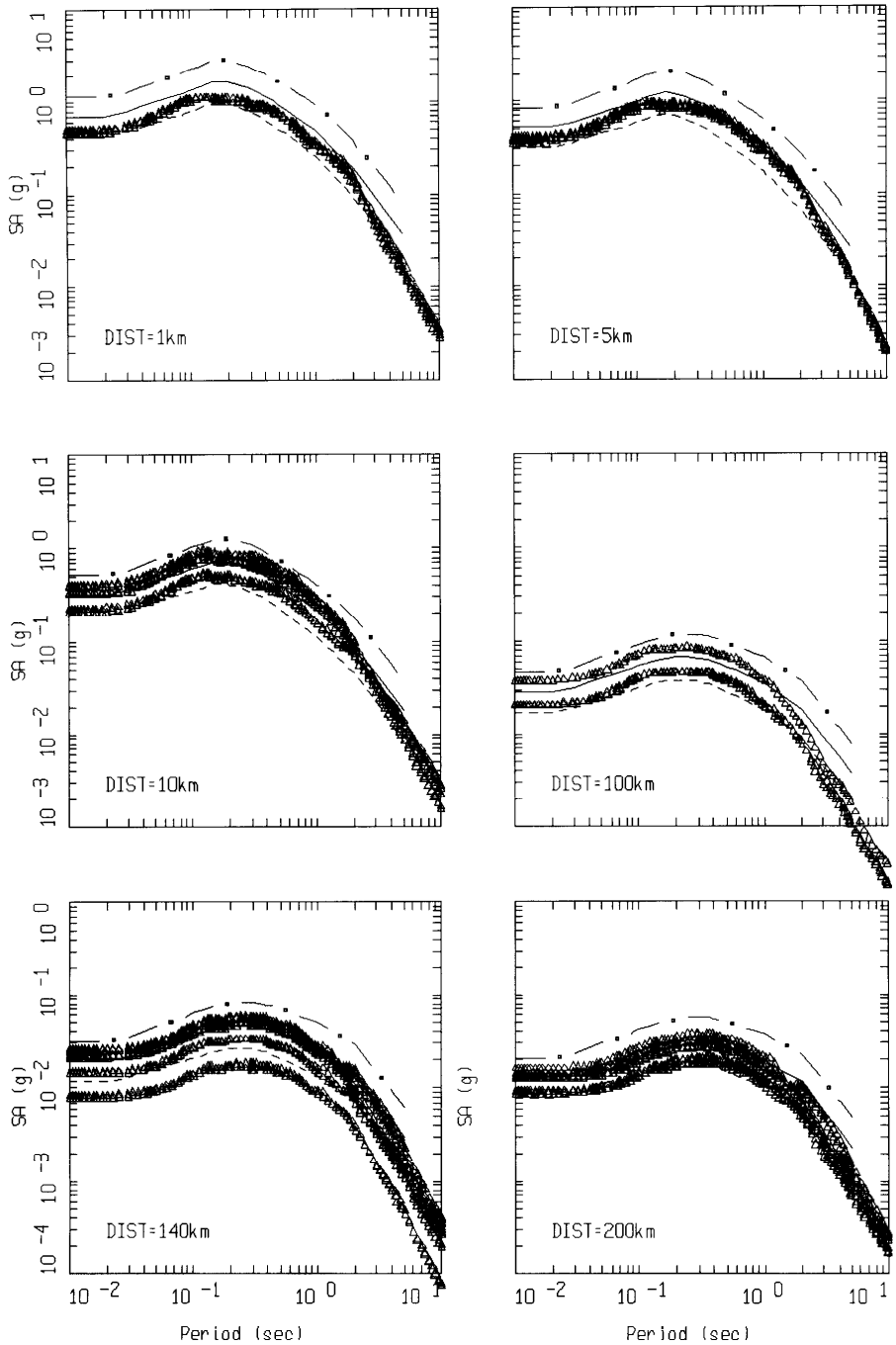

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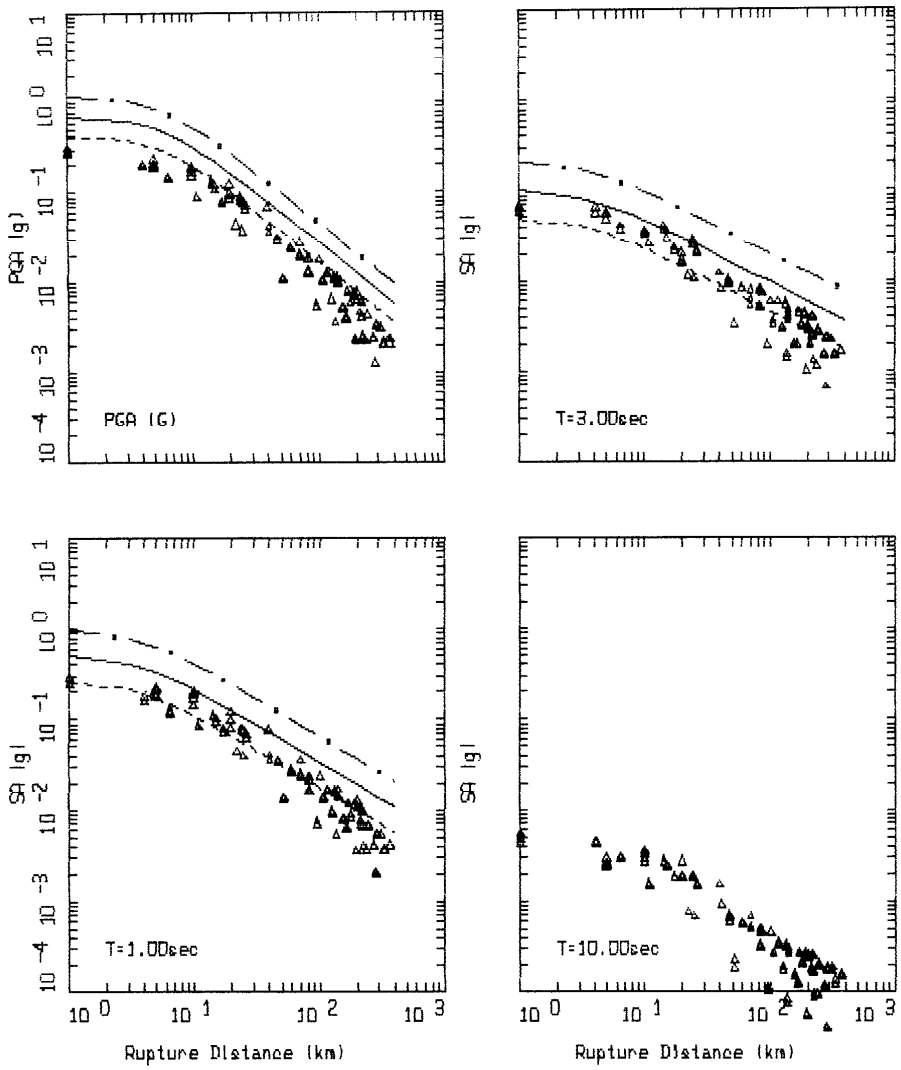

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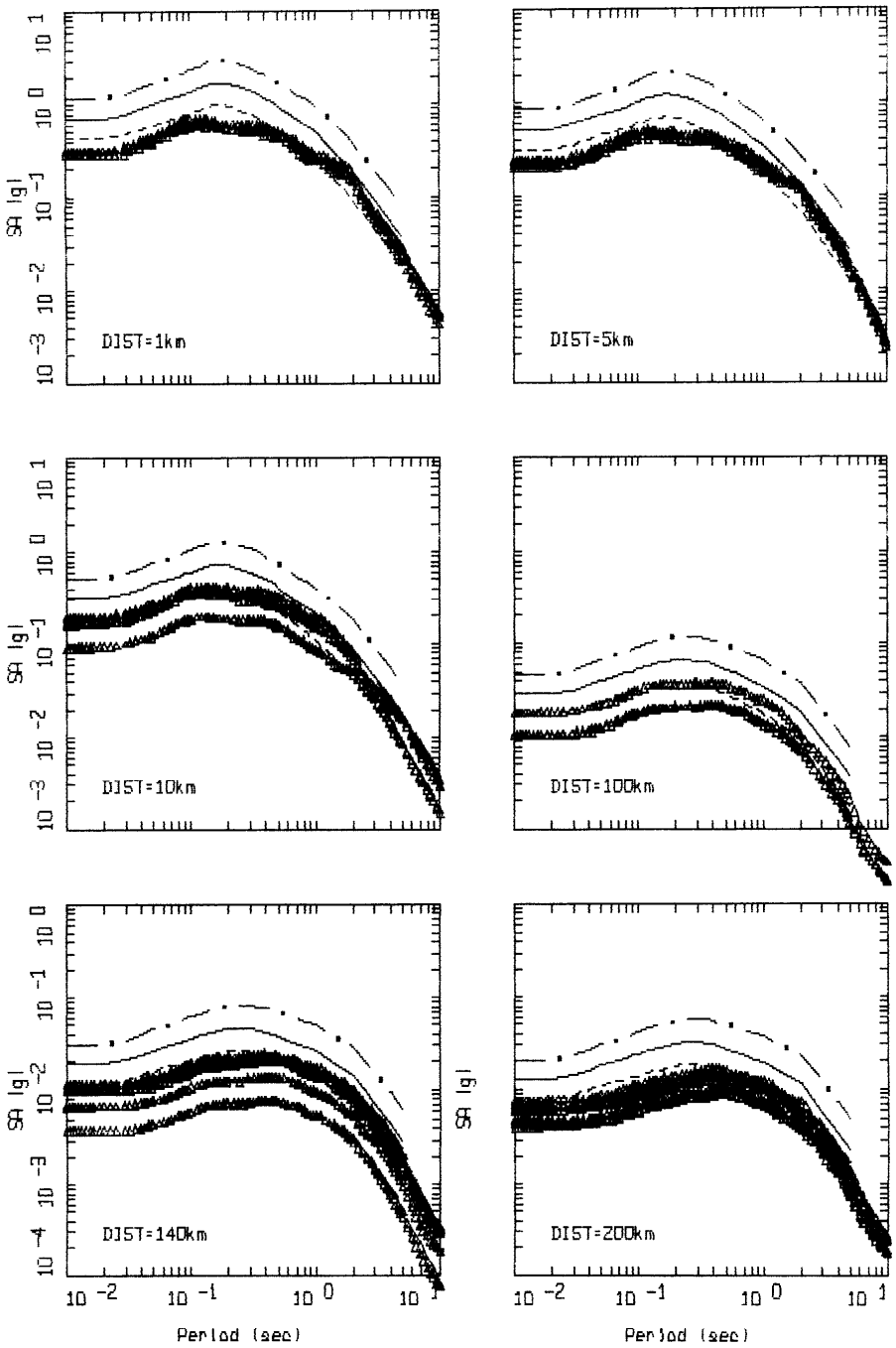

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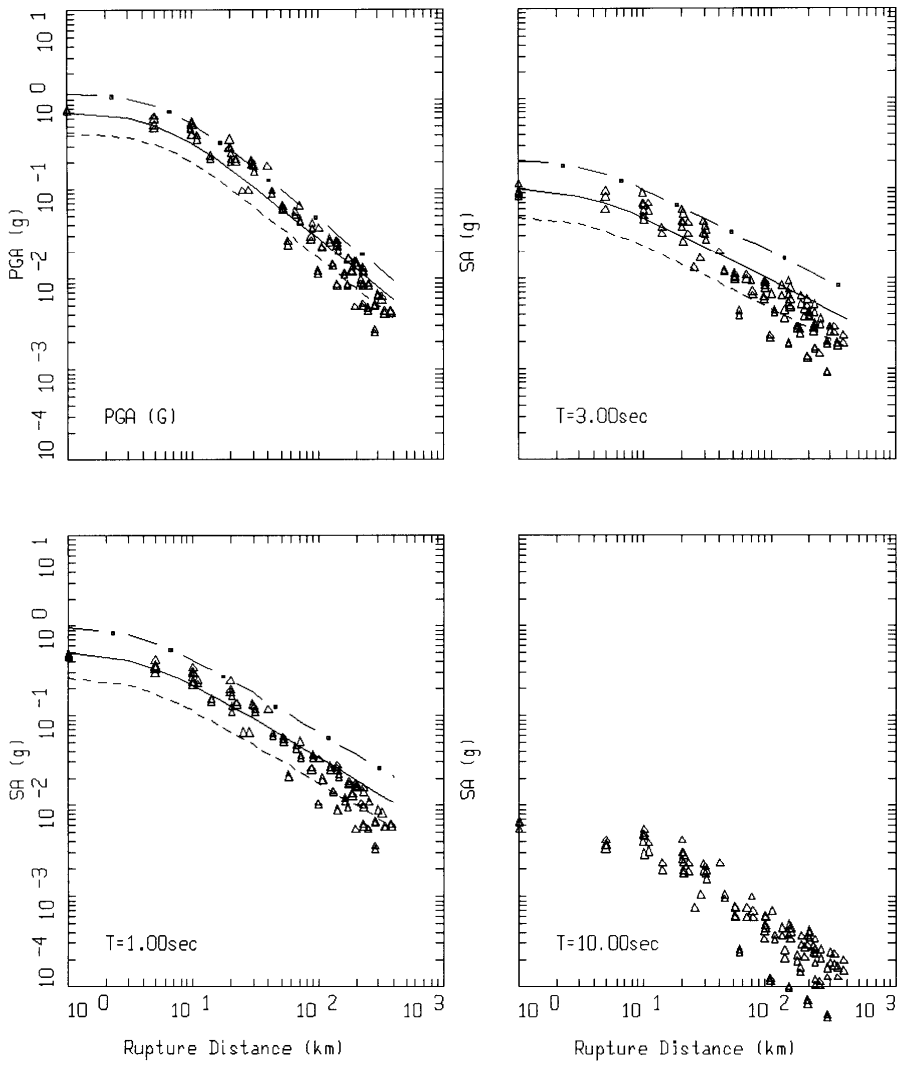

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PEER NGA FINITE FAULT MODELING, CASE: SC
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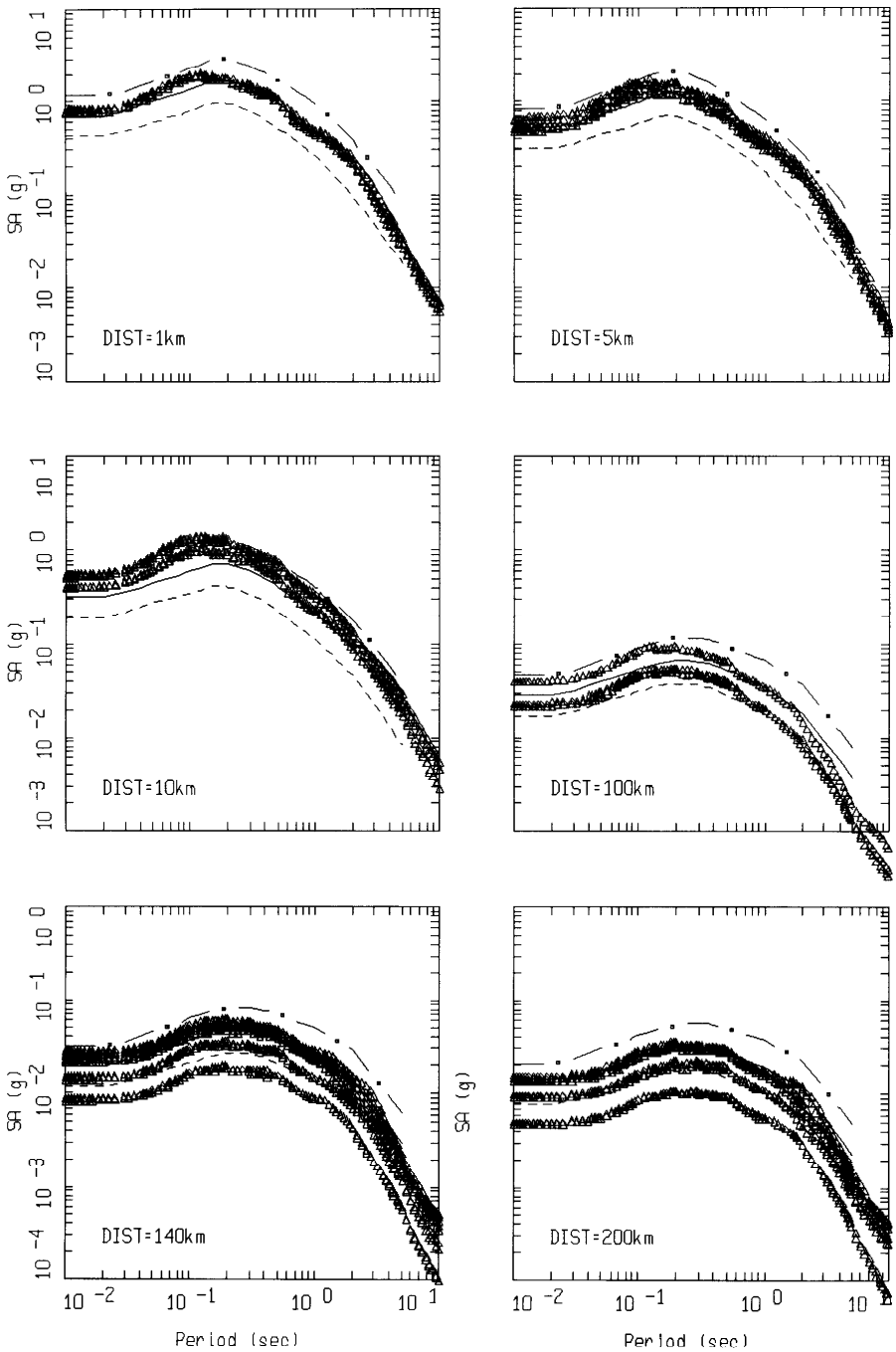

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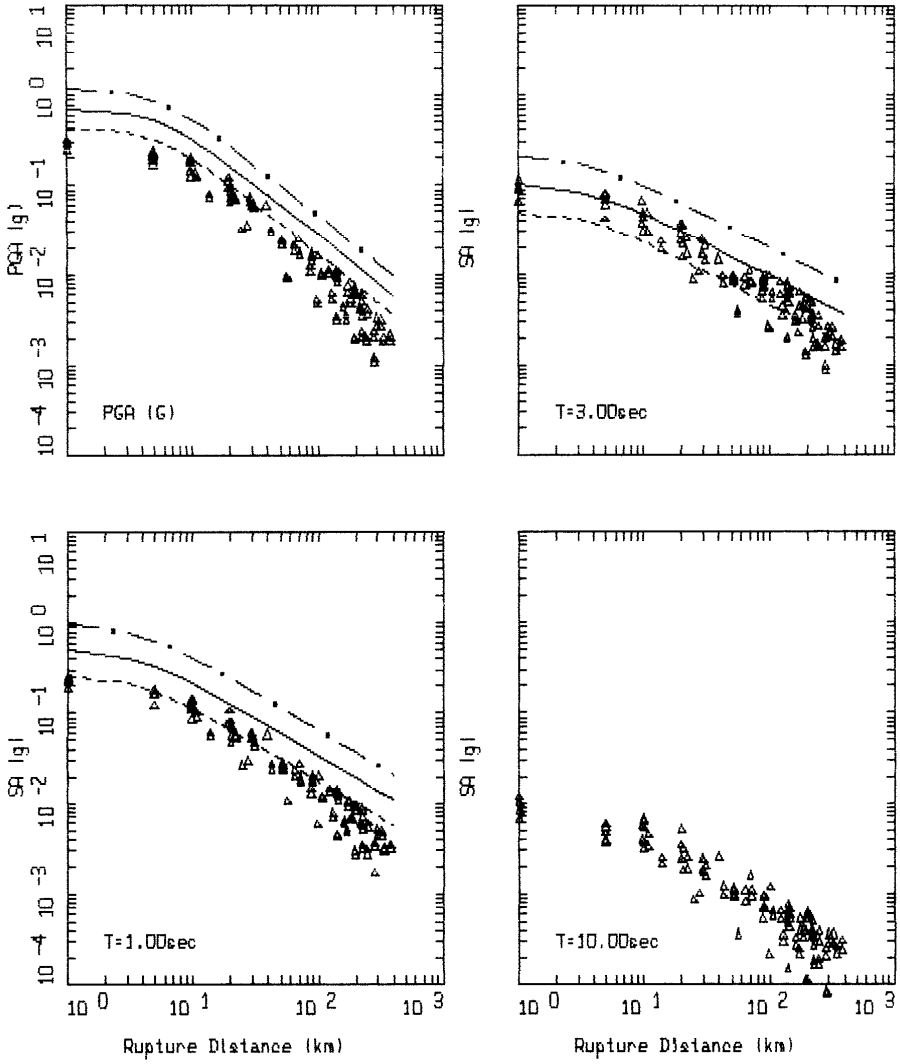

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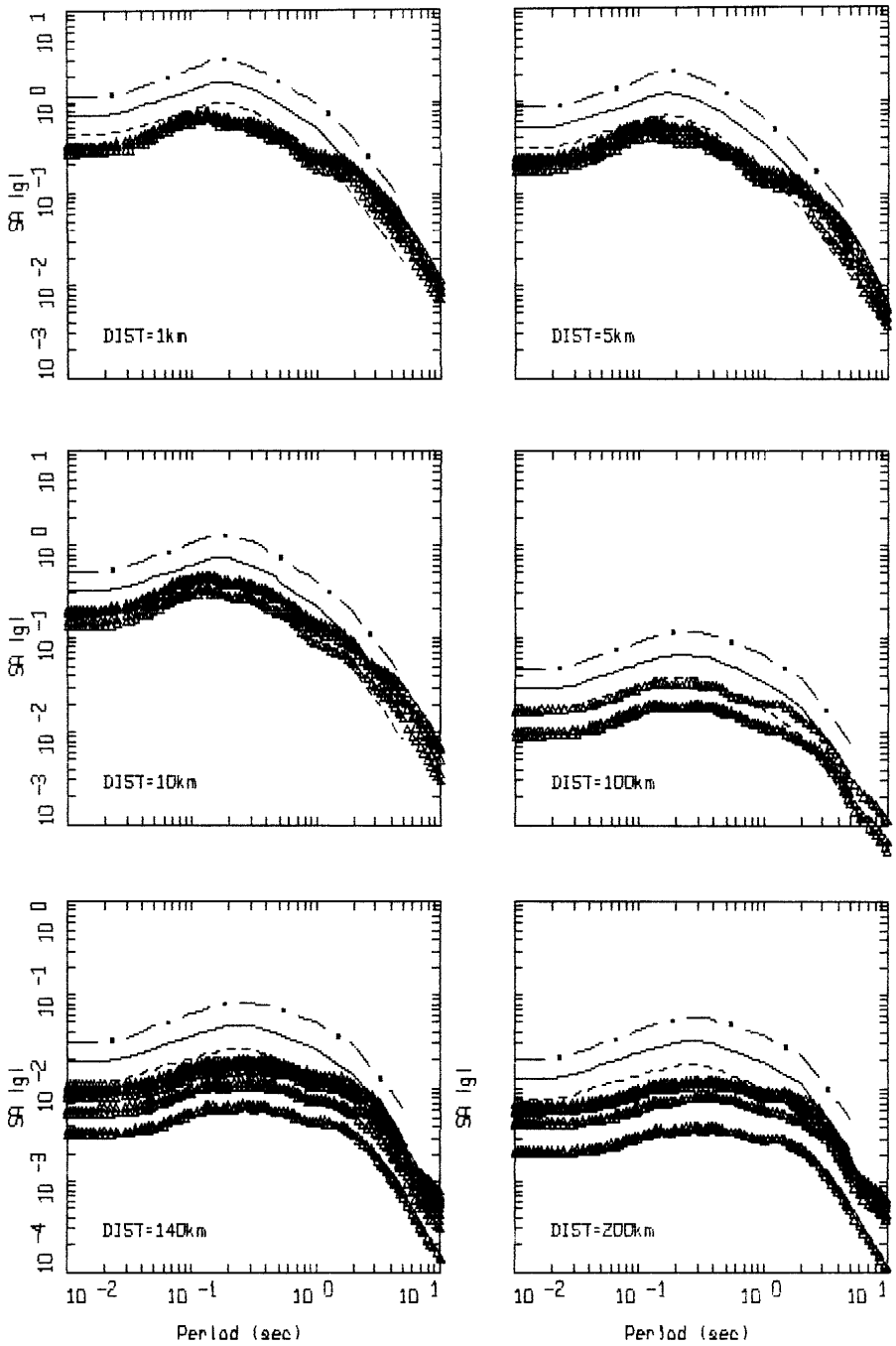

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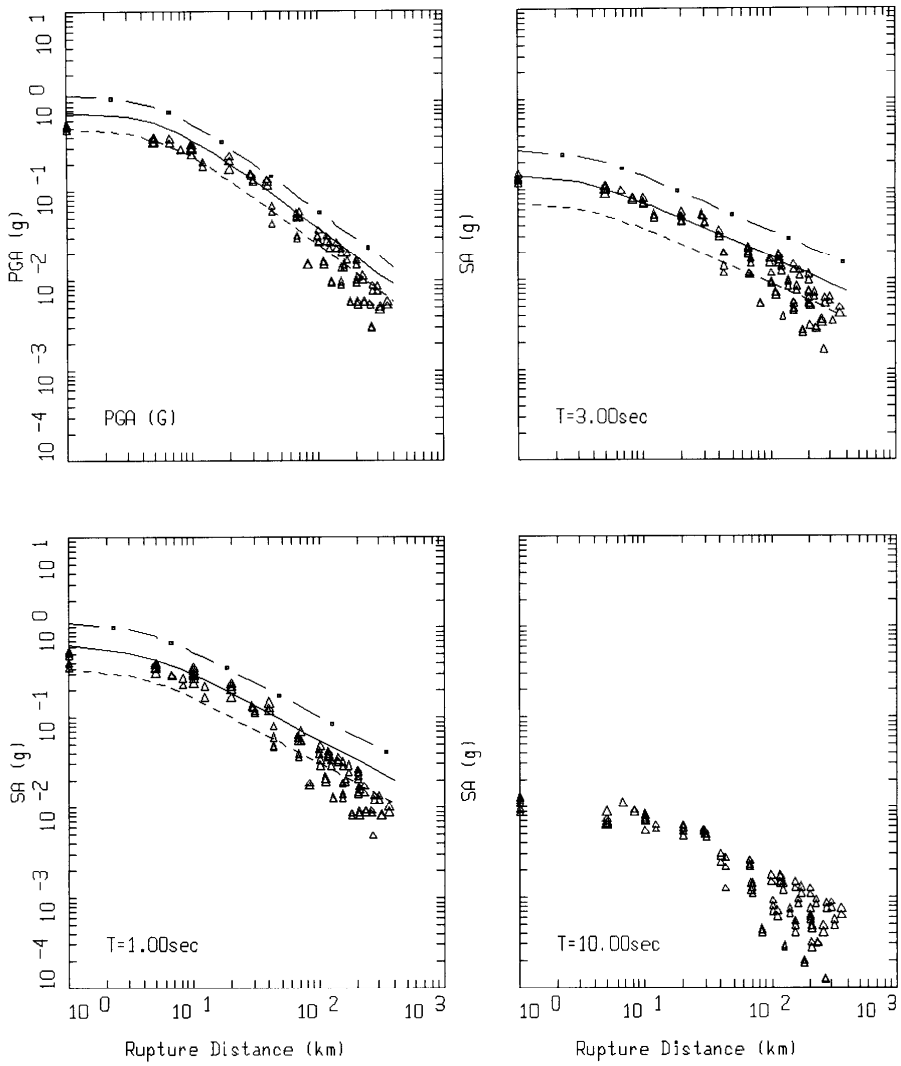

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- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: SD
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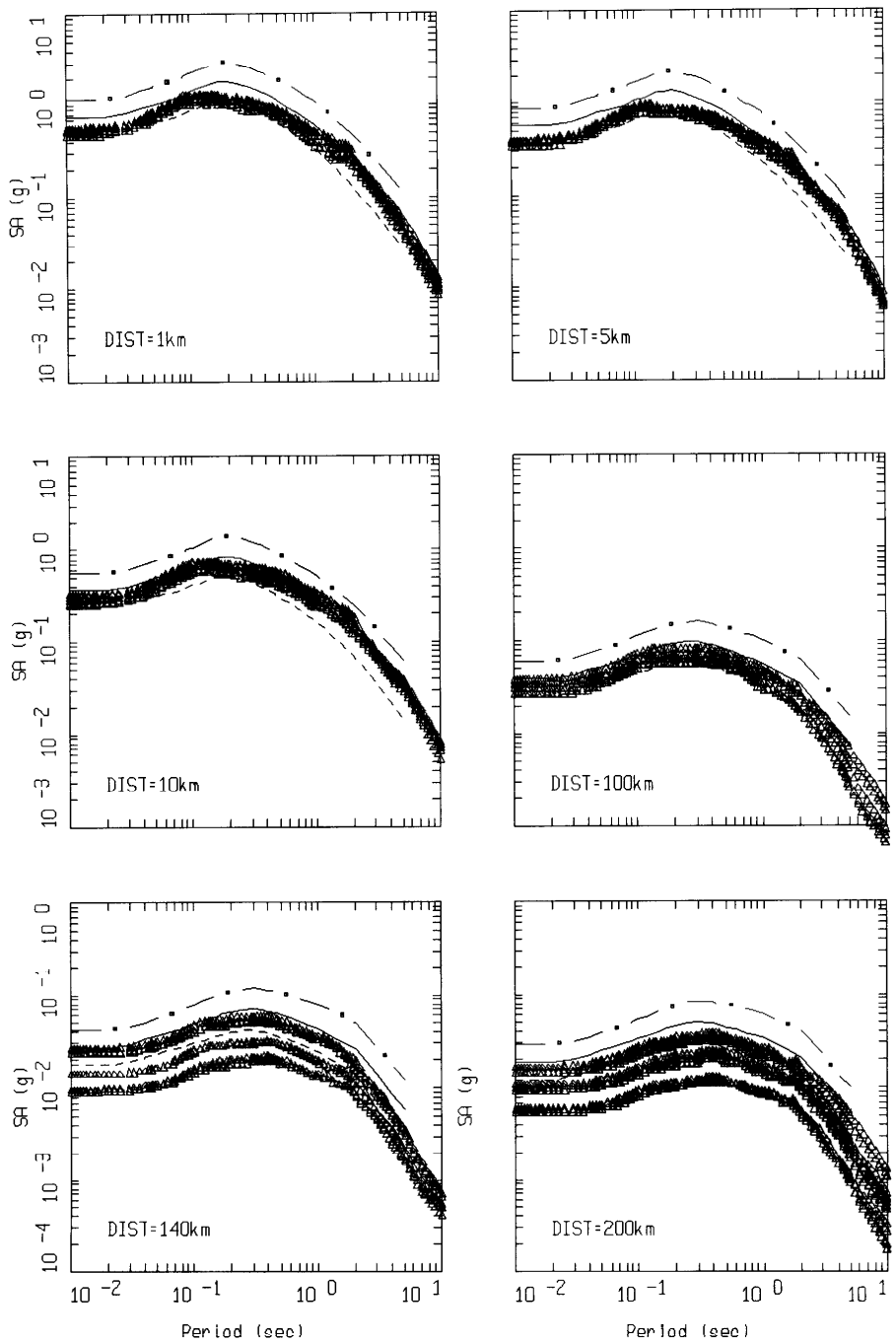

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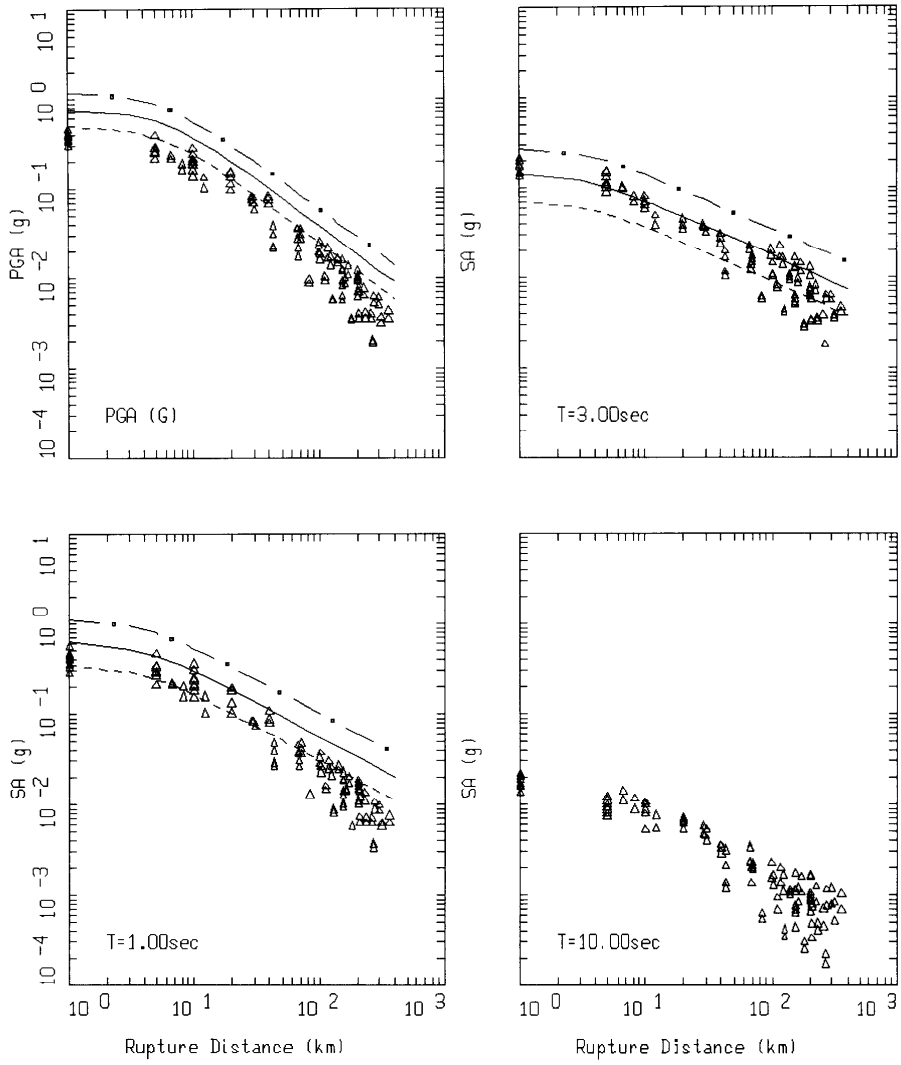

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———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: SD
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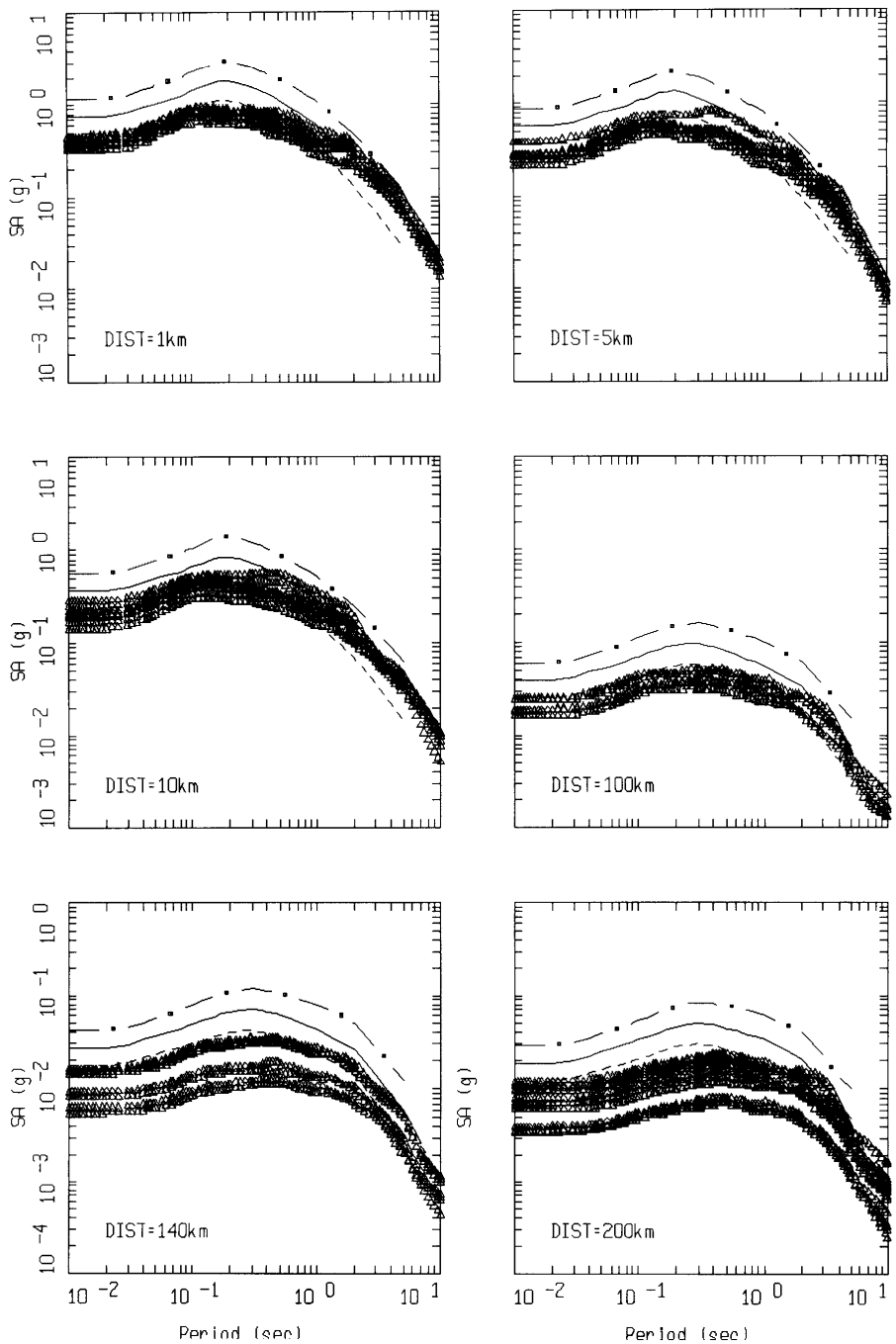

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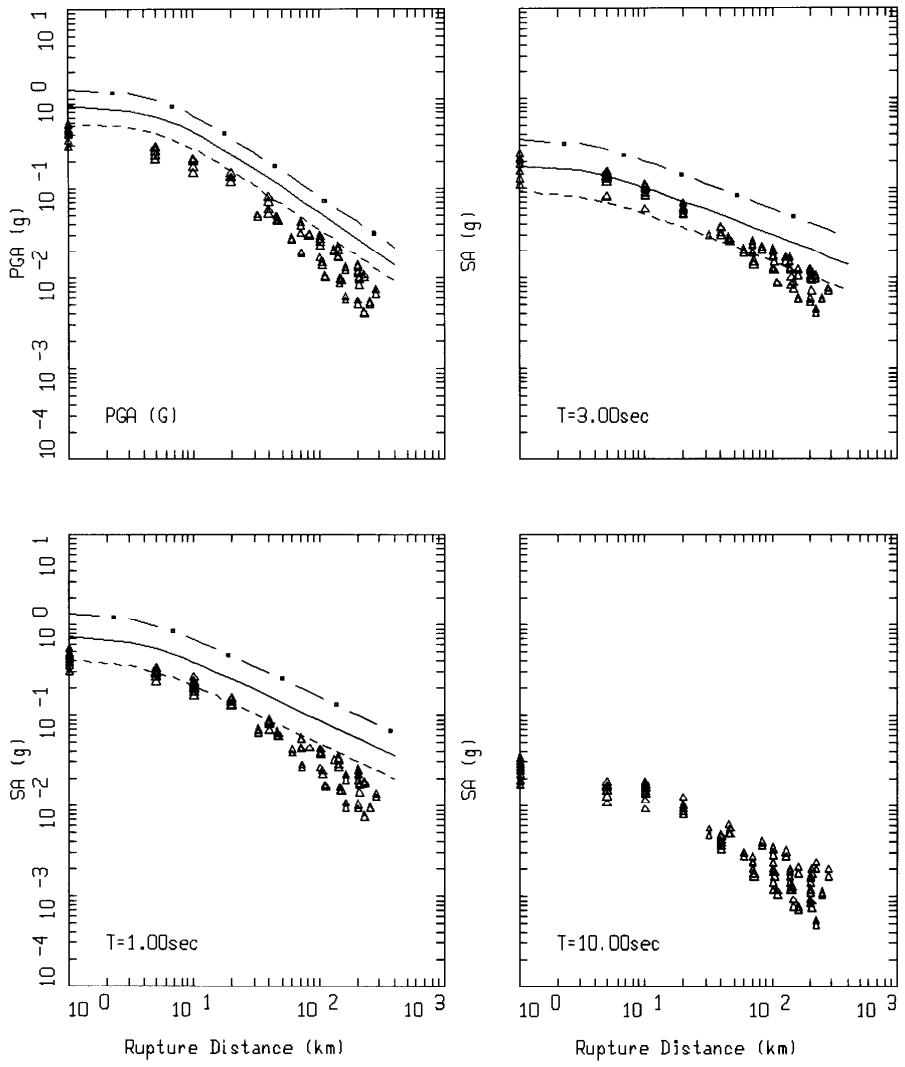

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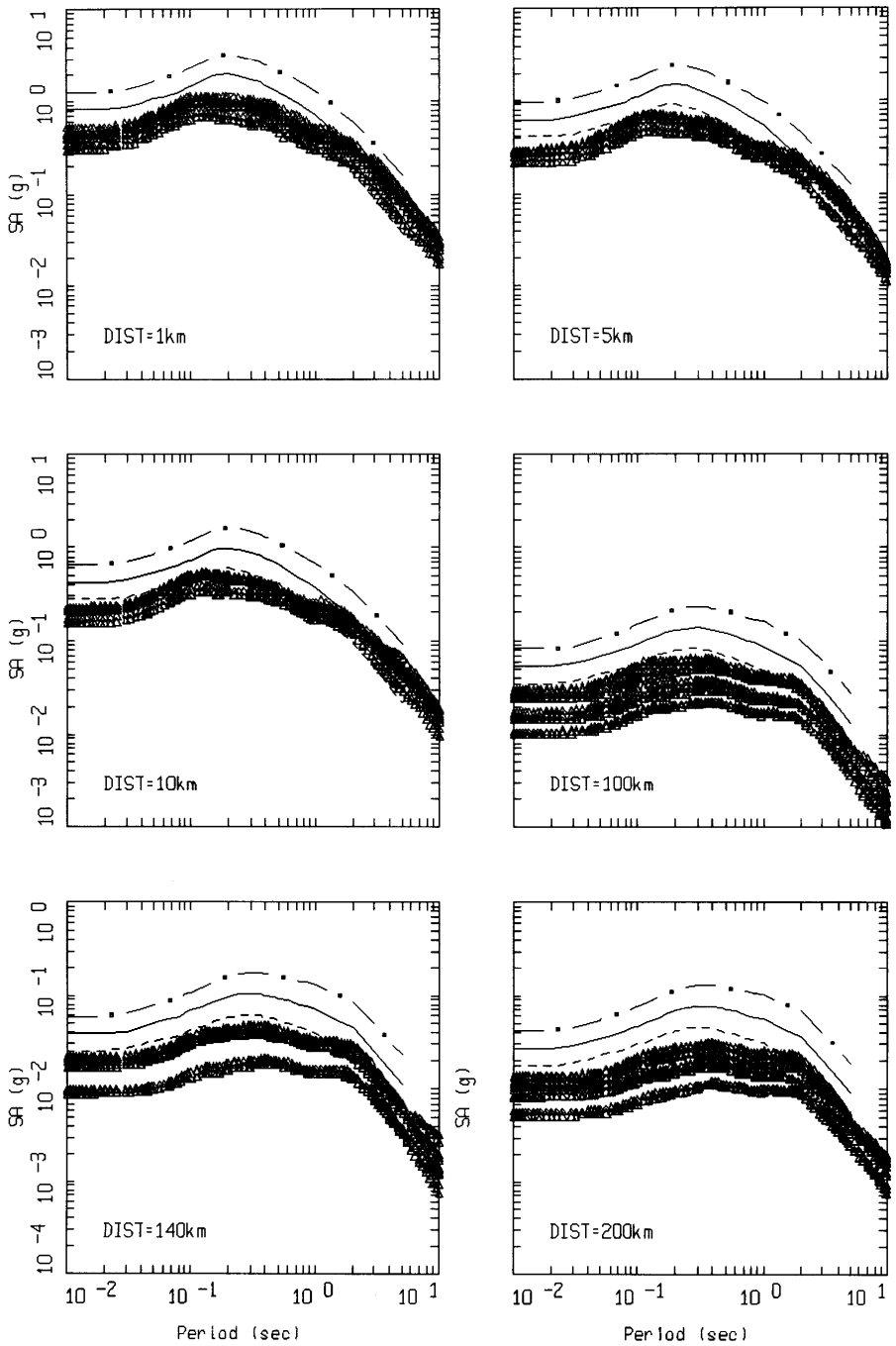

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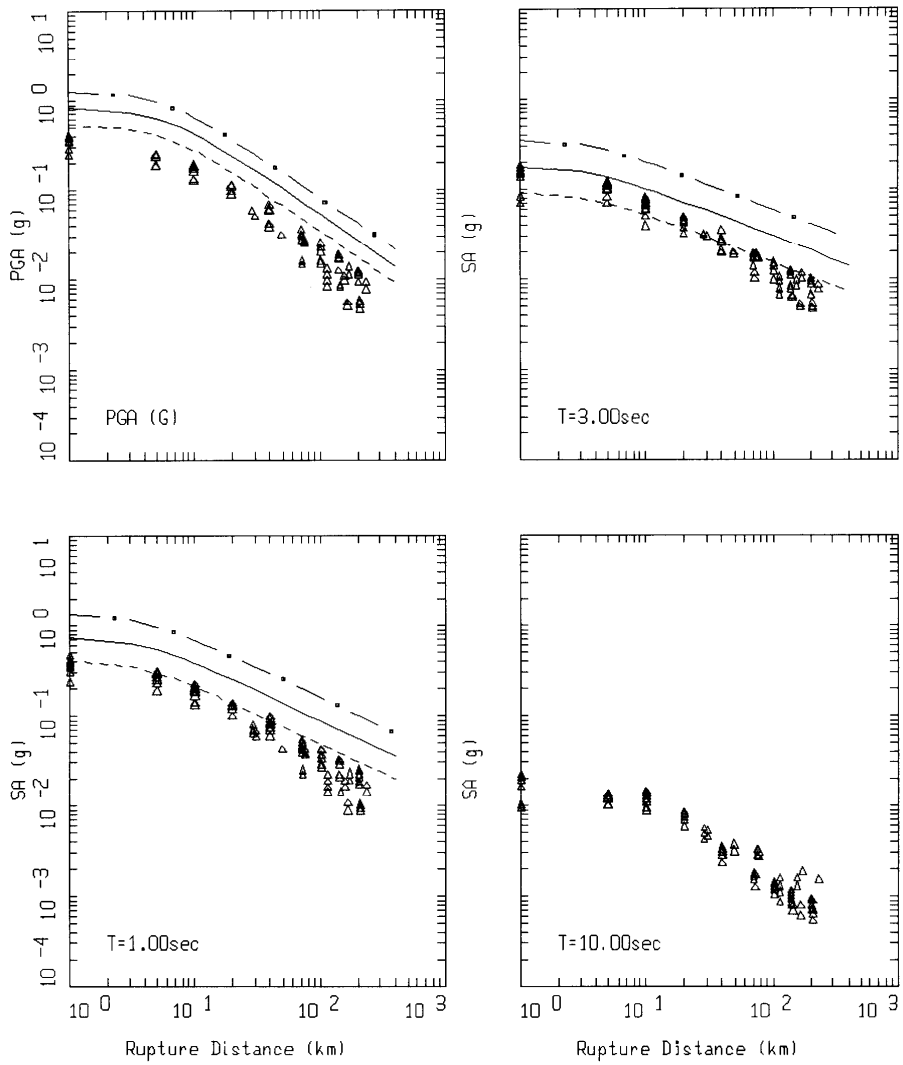

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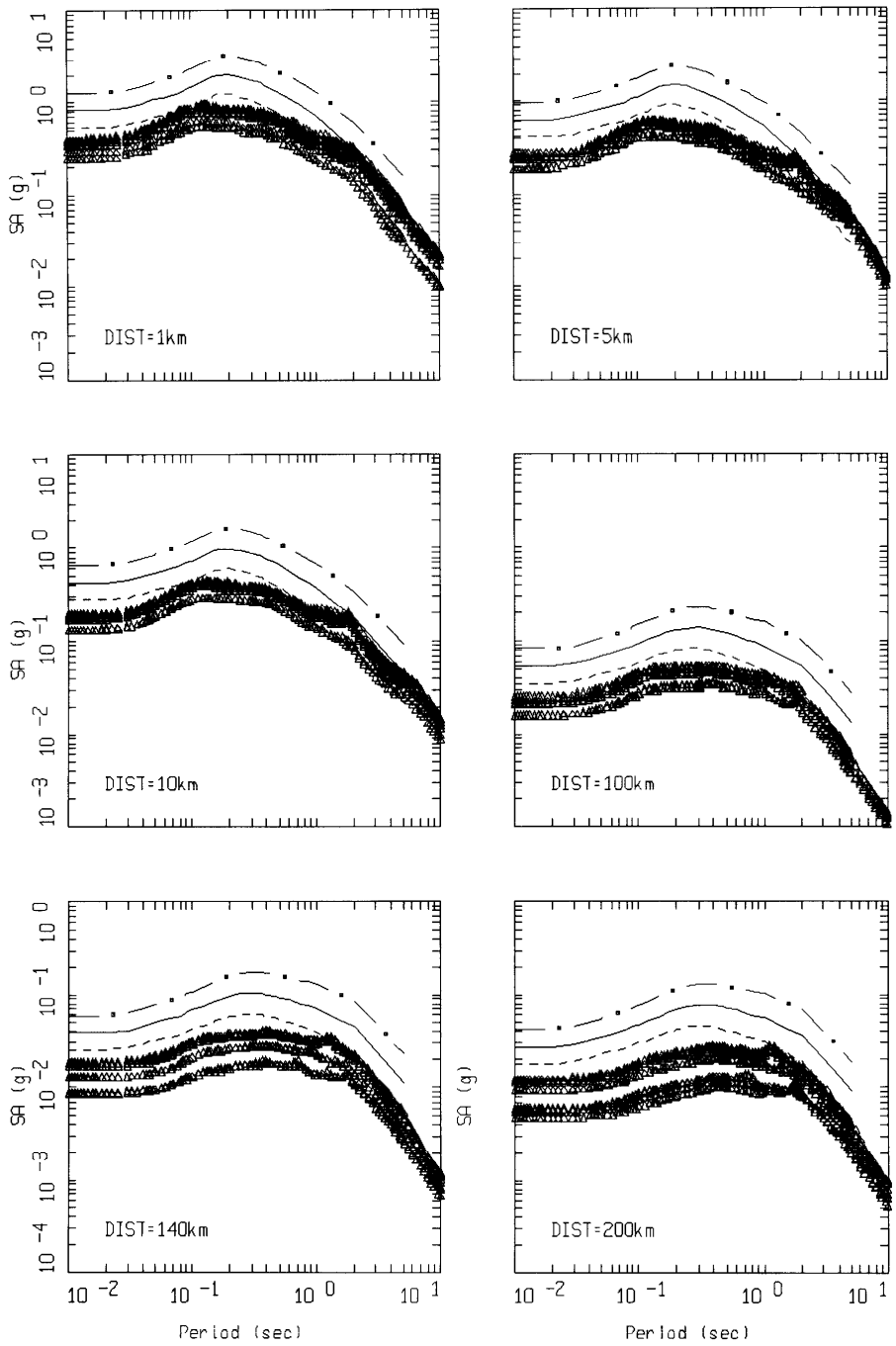

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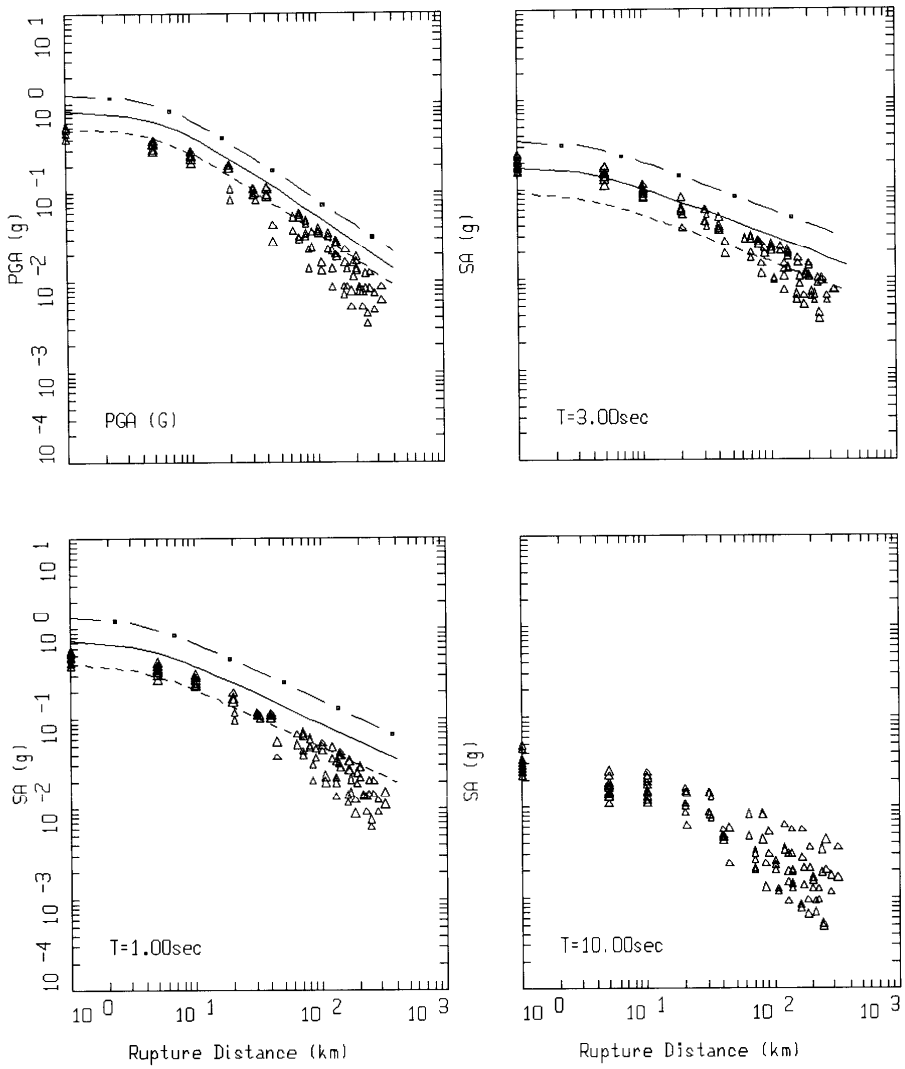

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PEER NGA FINITE FAULT MODELING, CASE: SG
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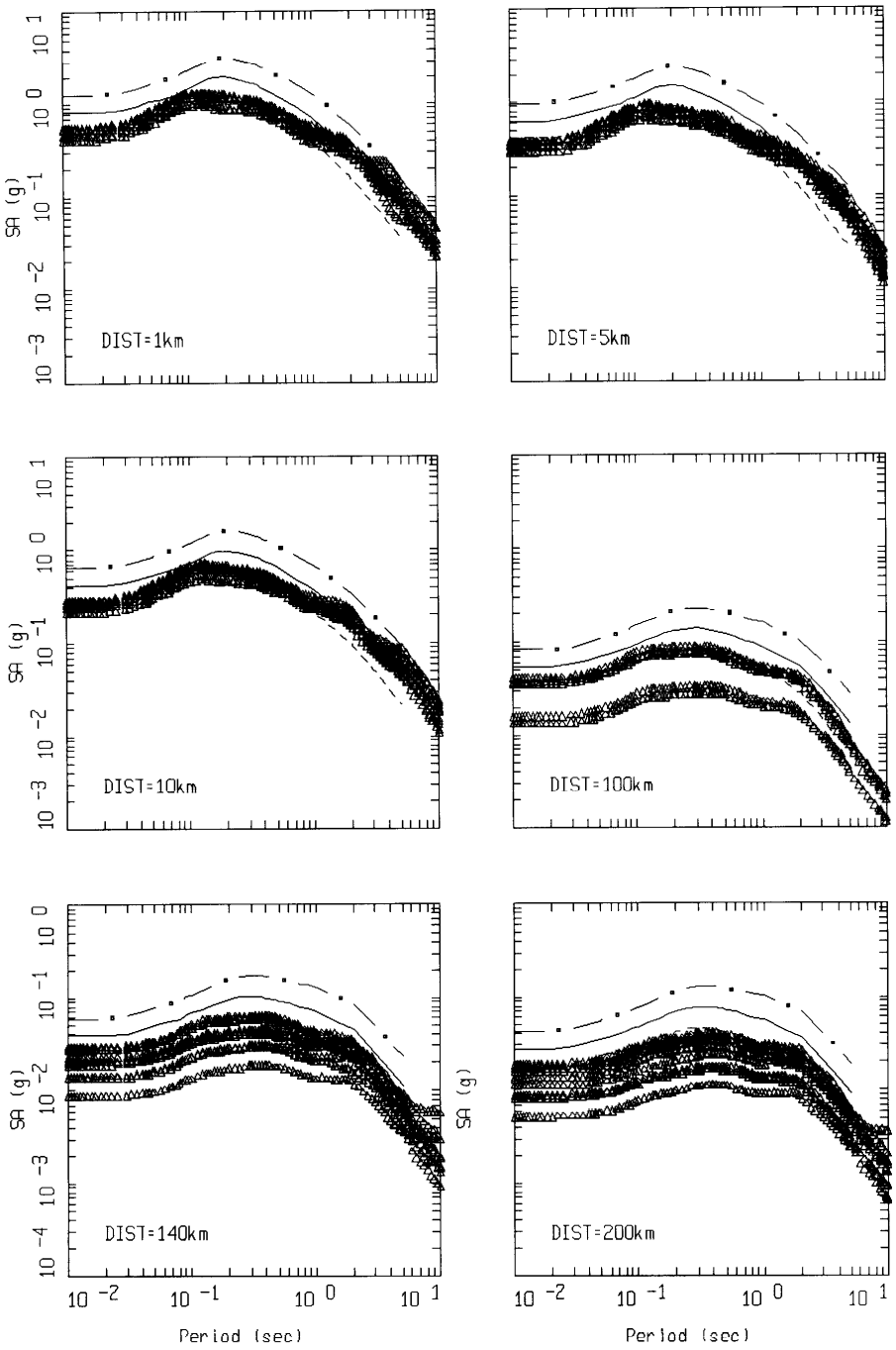

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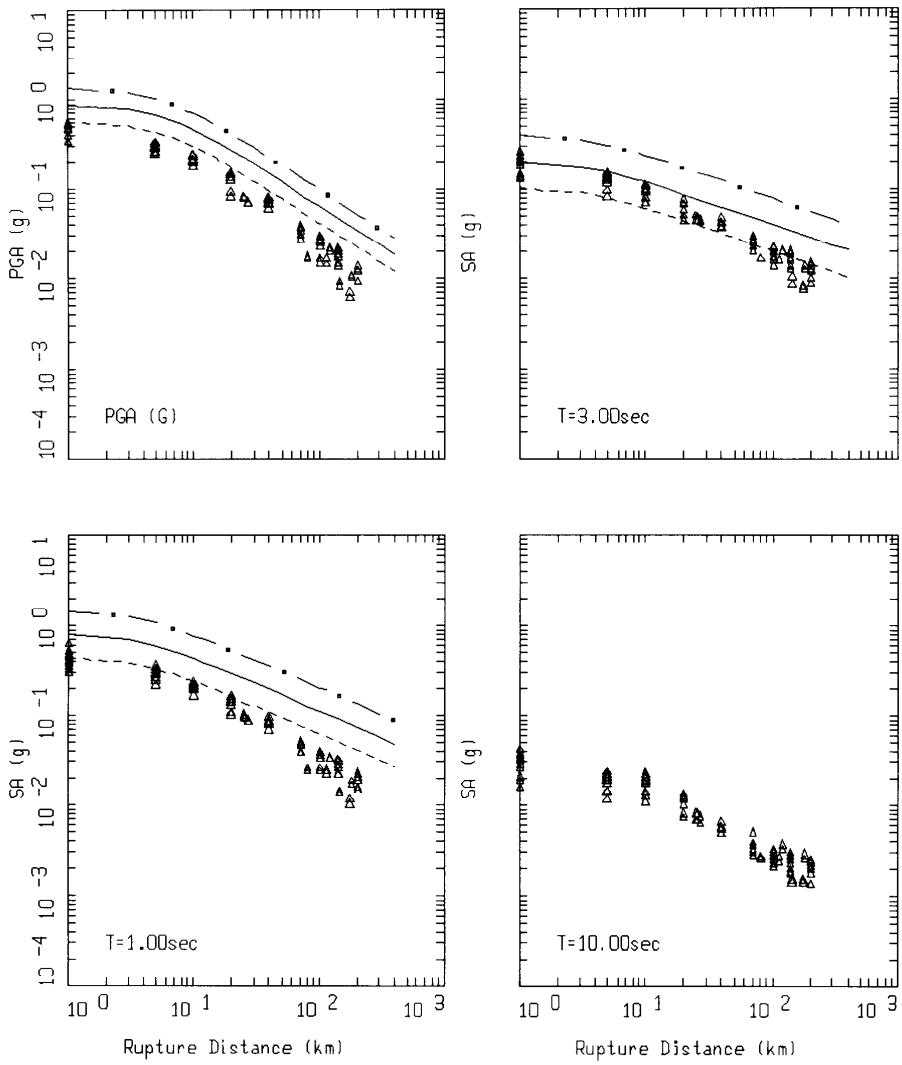

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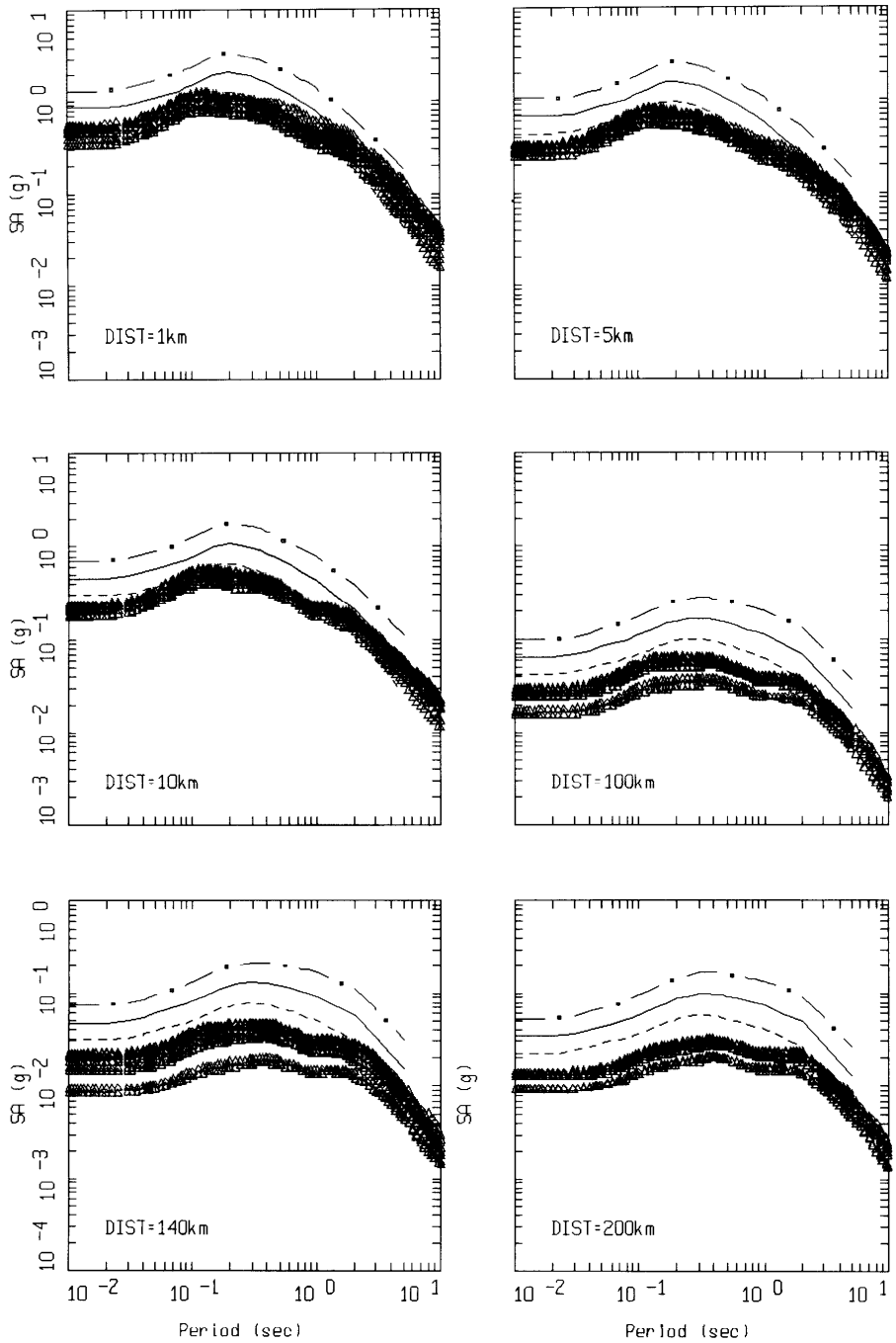
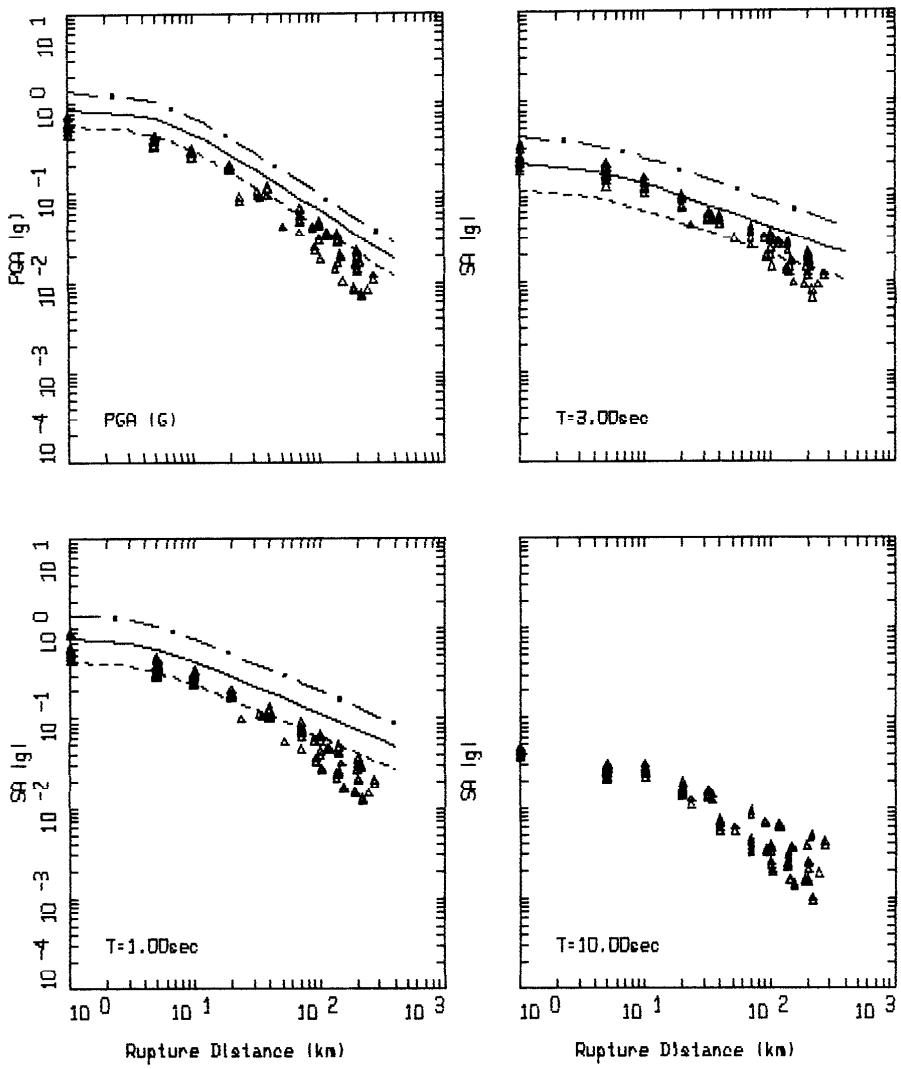
PEER NGA FINITE FAULT MODELING, CASE: SH
M=7.8, L=420km, W=13km, DIP=90



PEER NGA FINITE FAULT MODELING, CASE: SH
M=7.8, L=420km, W=15km, DIP=90



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PEER NGA FINITE FAULT MODELING, CASE: SI
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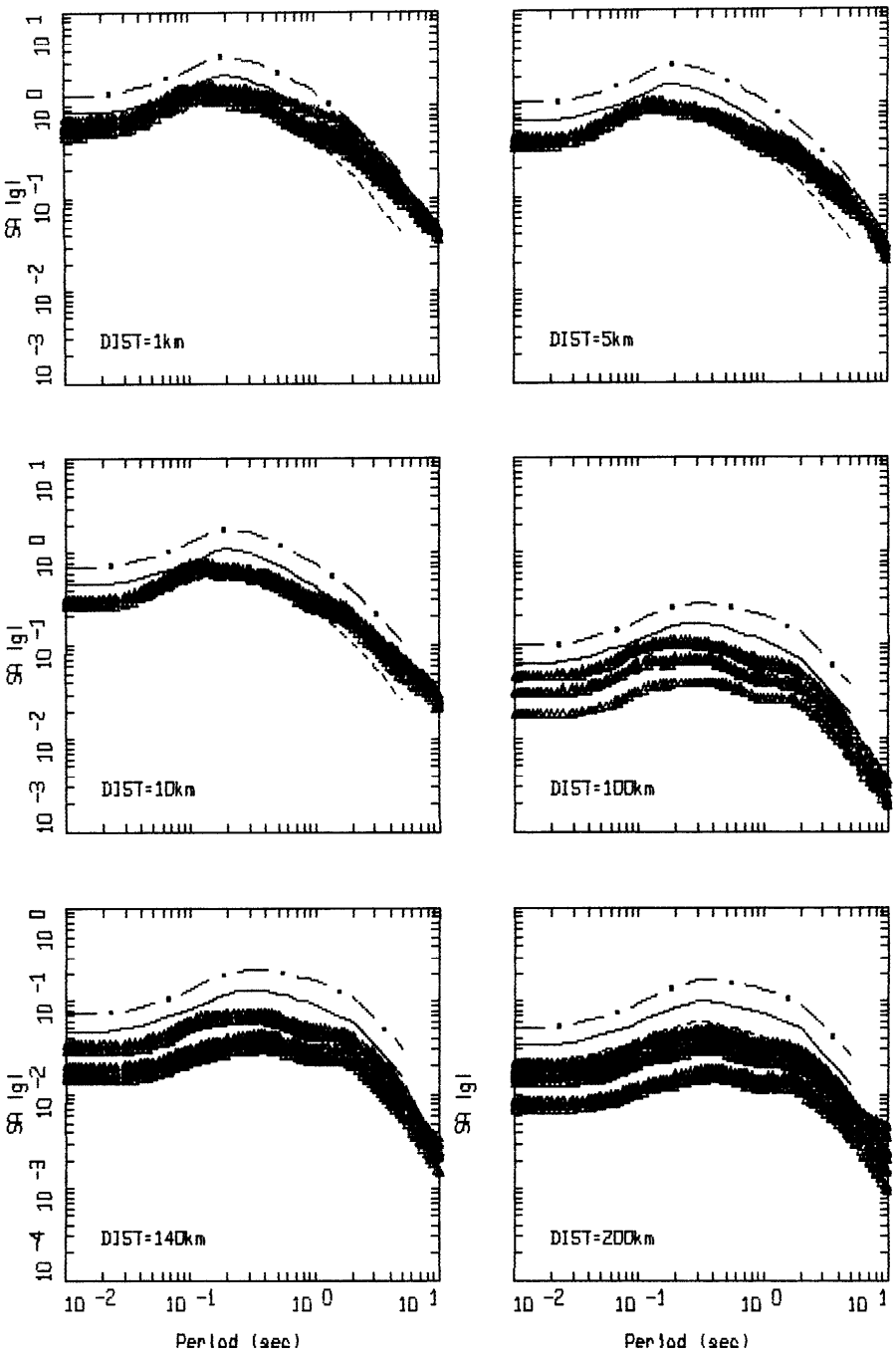

PEER NGA FINITE FAULT MODELING, CASE: SI

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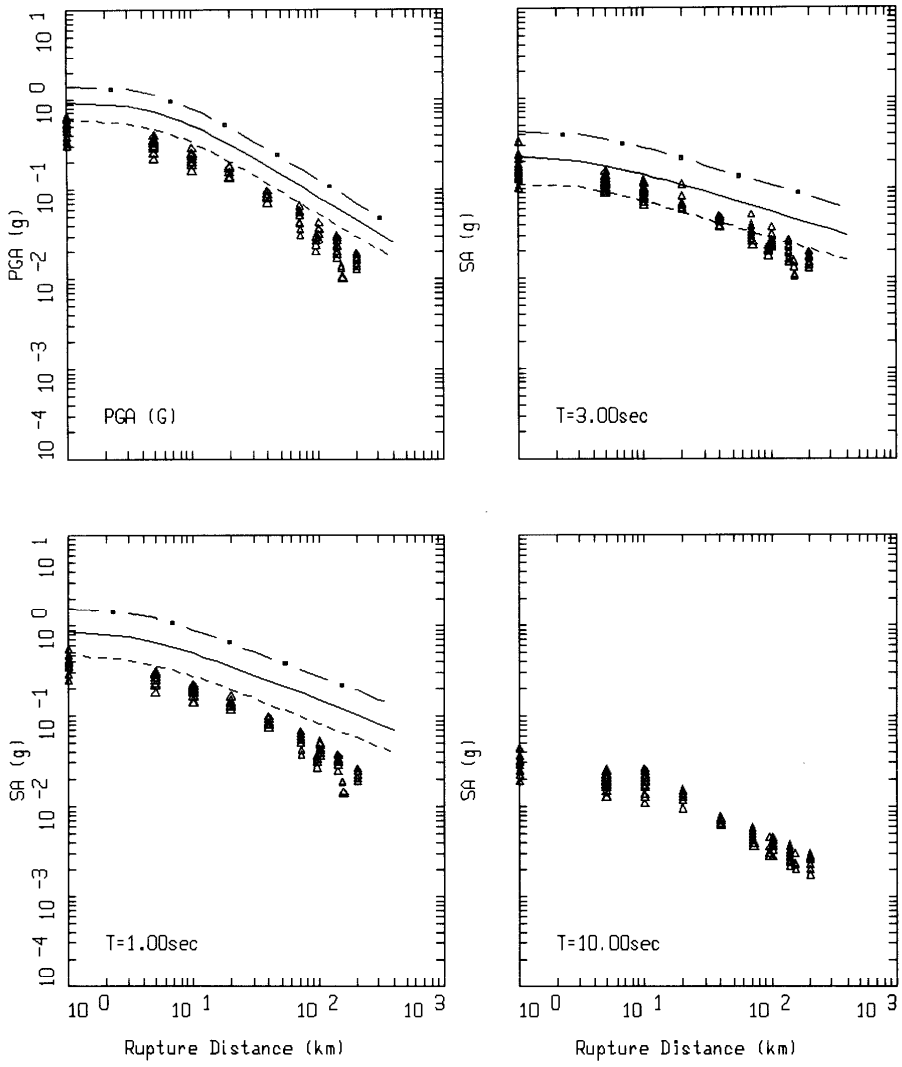

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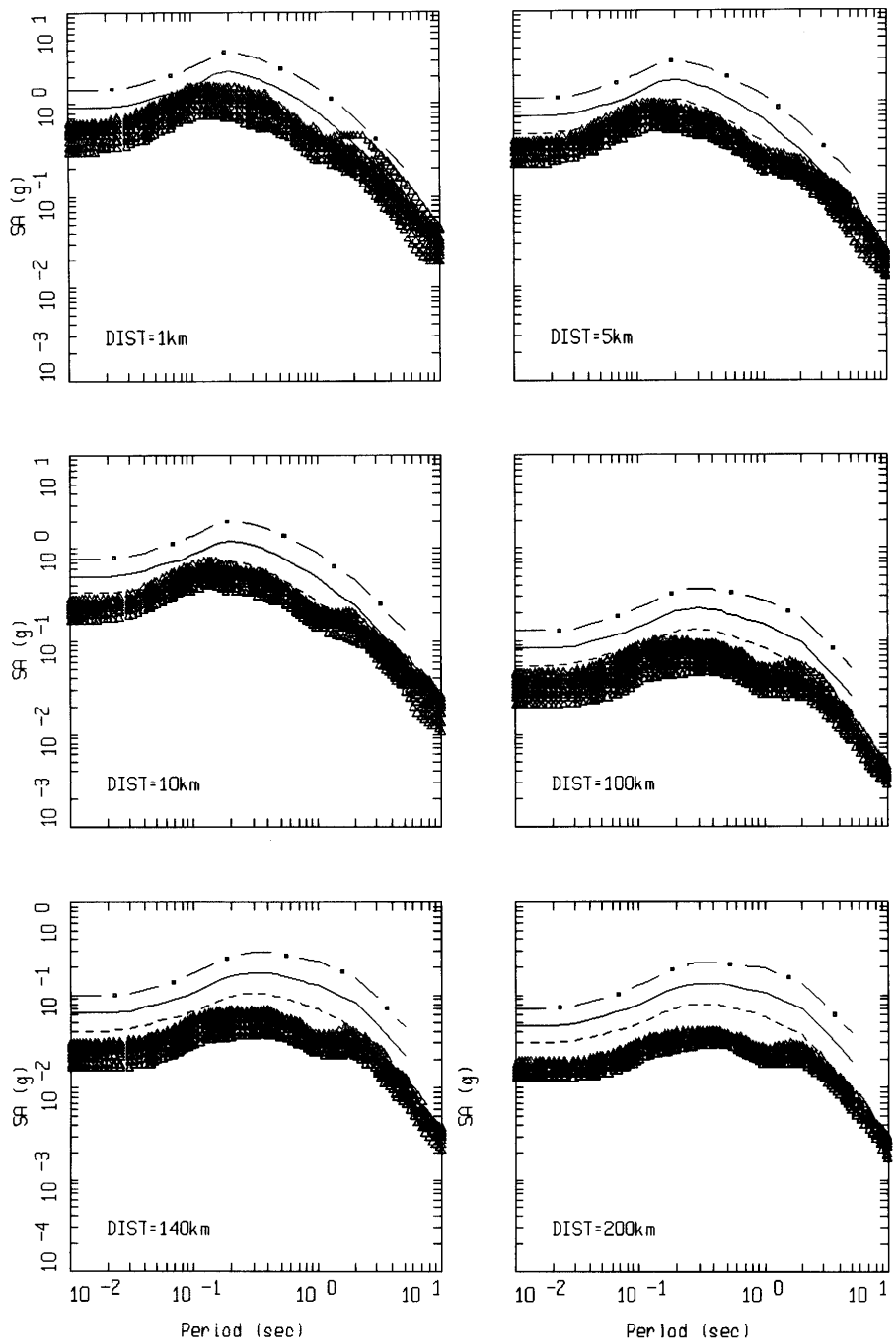
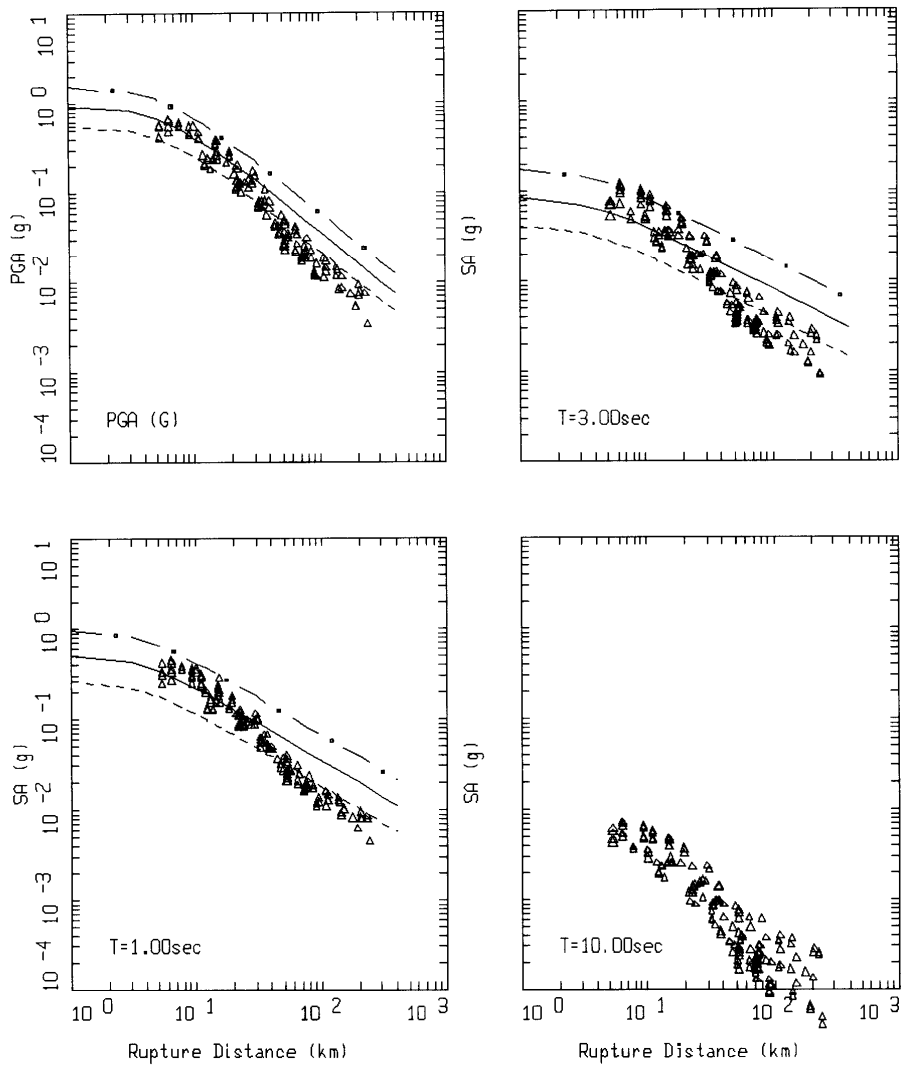


PEER NGA FINITE FAULT MODELING, CASE: SJ
M=8.2, L=470km, W=15km, DIP=90

Figure Set 2. Reverse-Slip Mechanisms



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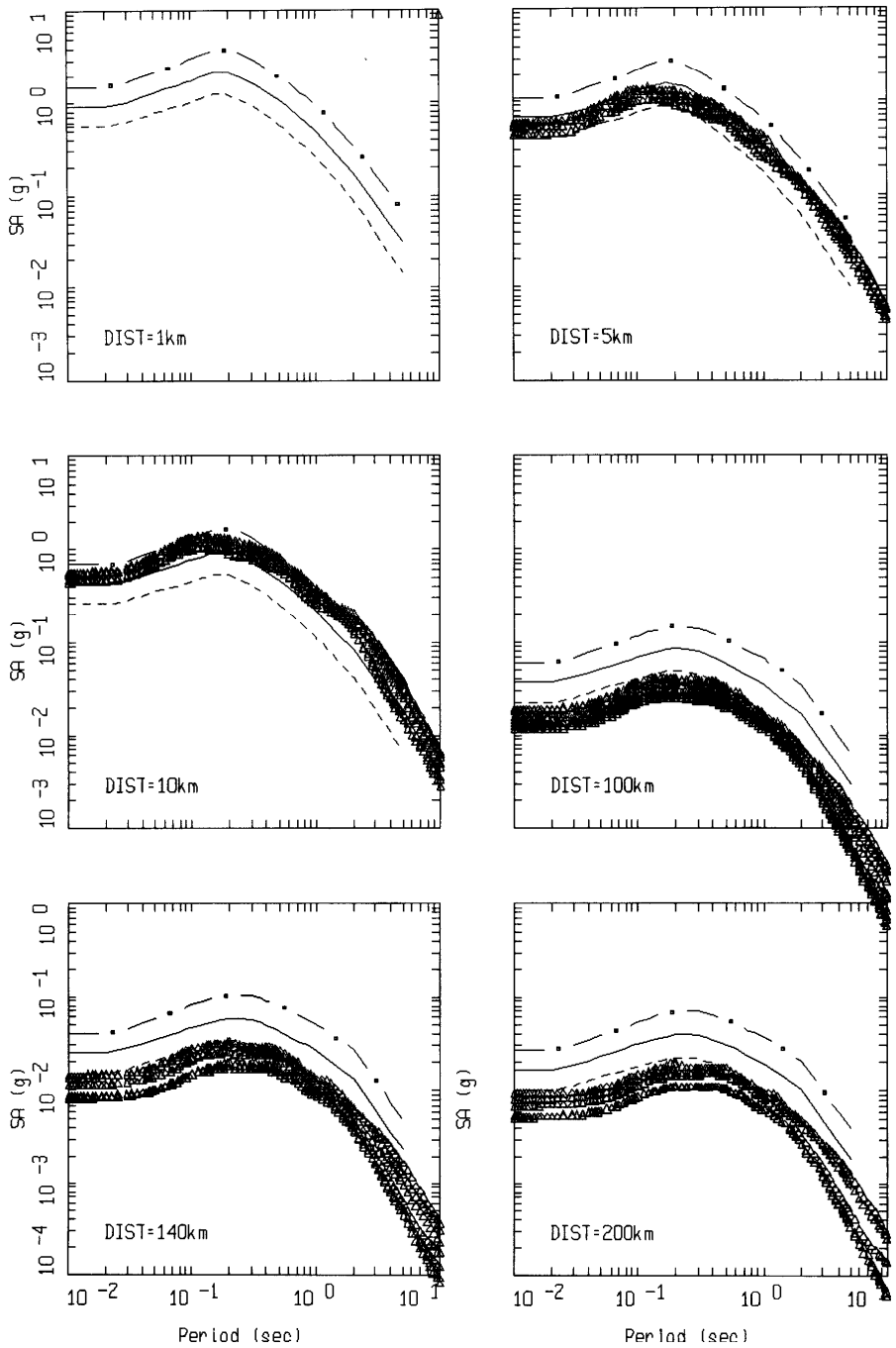
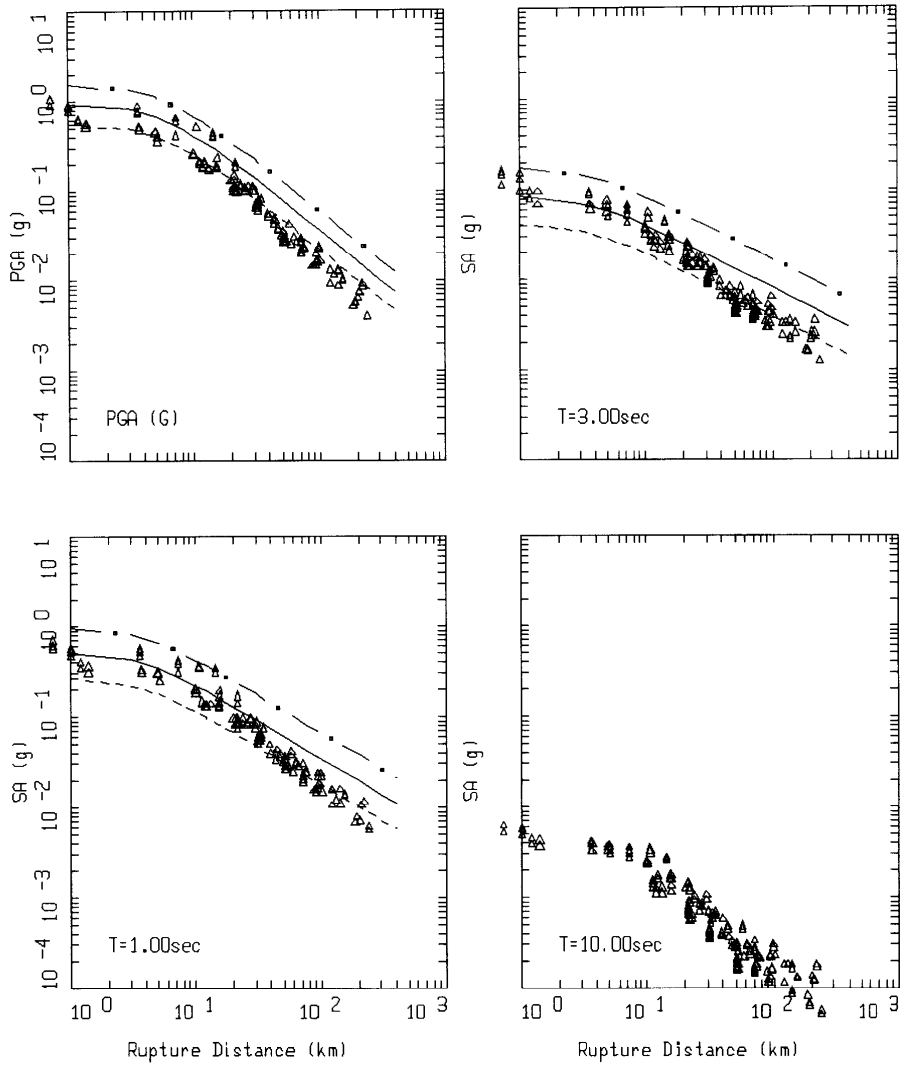
—— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RA
M=6.5, L=18km, W=18km, DIP=30, DEEP SLIP



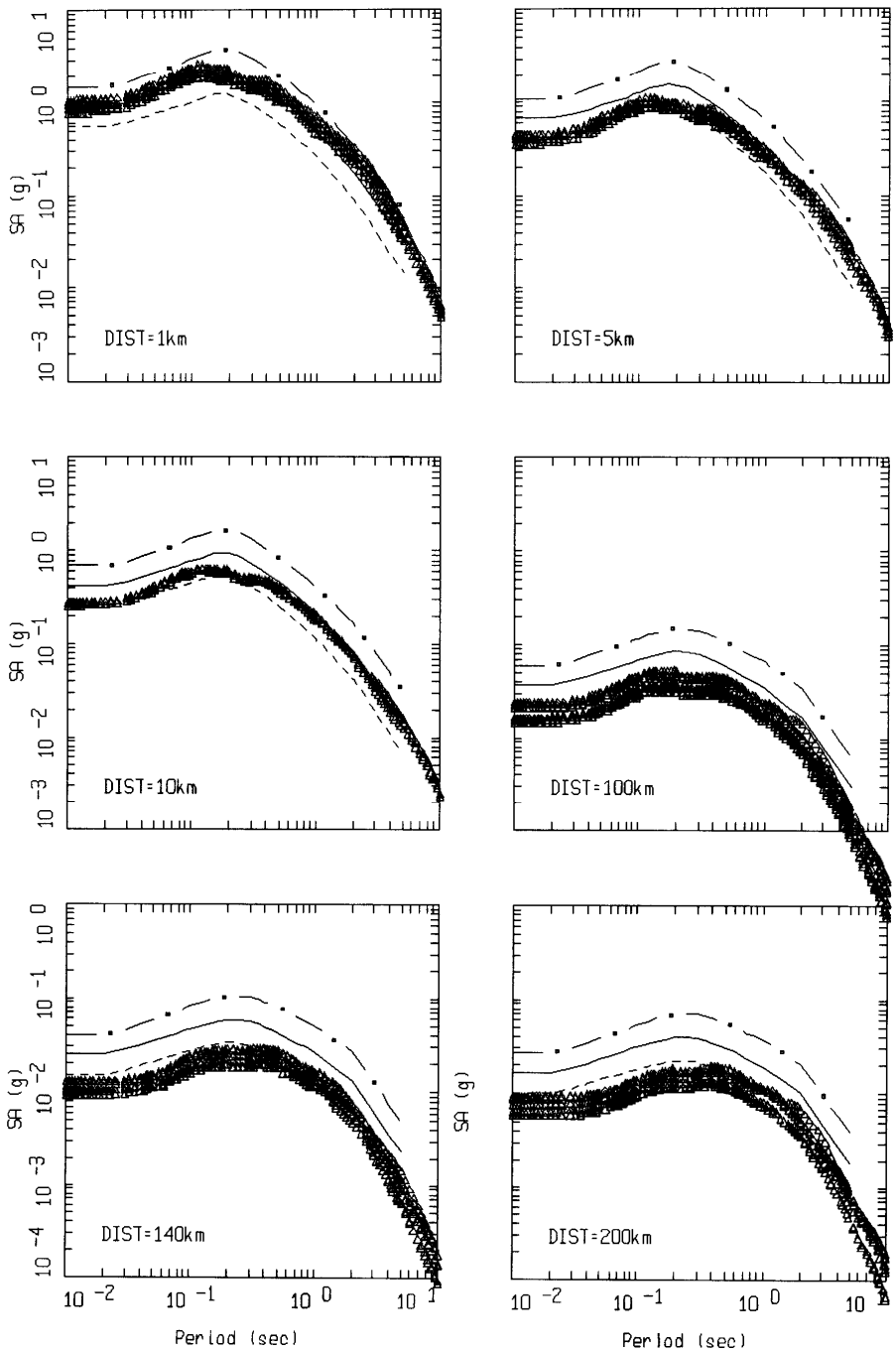
PEER NGA FINITE FAULT MODELING, CASE: RA
M=6.5, L=18km, W=18km, DIP=30, DEEP SLIP



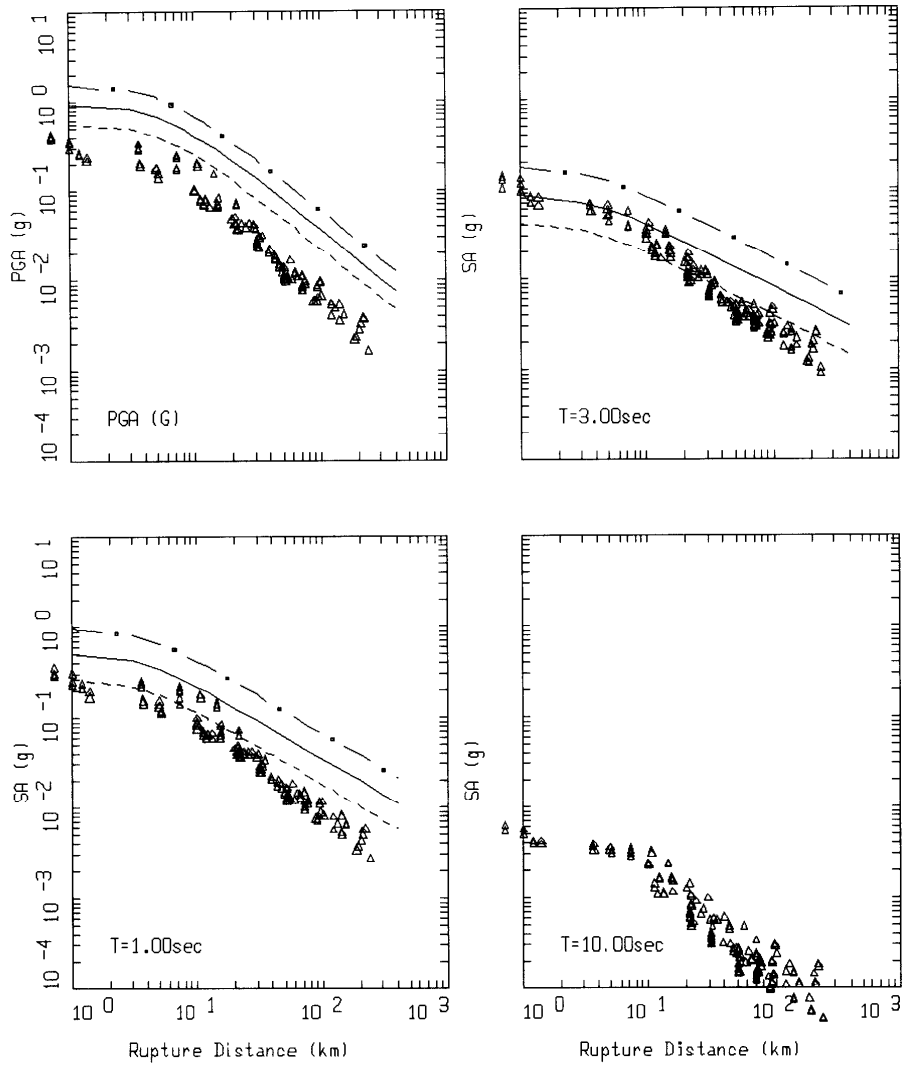
LEGEND

△ △	PEER SIMULATIONS, CASE RB, T=1.00 SEC
—— • ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RB
M=6.5, L=18km, W=18km, DIP=45, DEEP SLIP



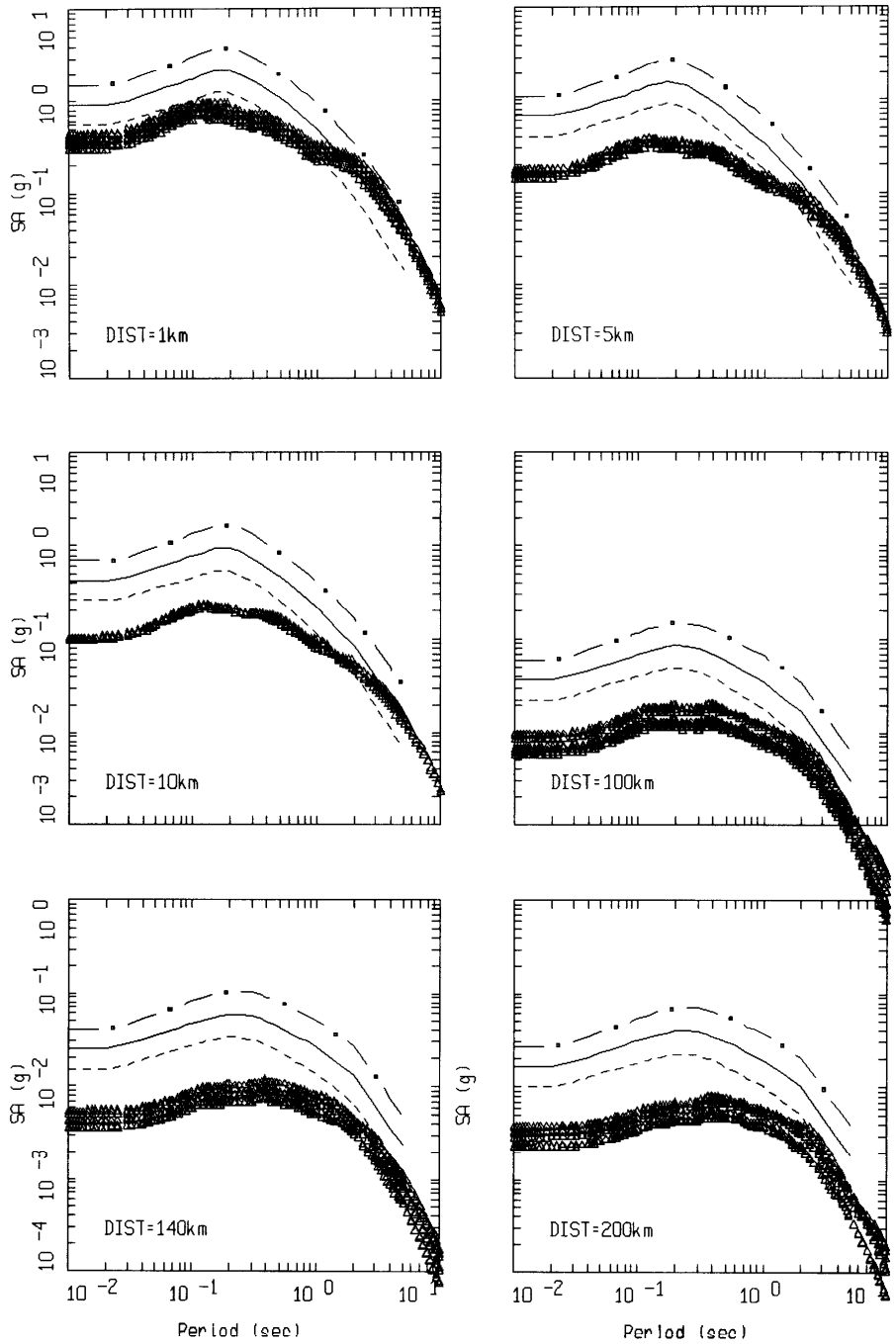
PEER NGA FINITE FAULT MODELING, CASE: RB
M=6.5, L=18km, W=18km, DIP=45, DEEP SLIP



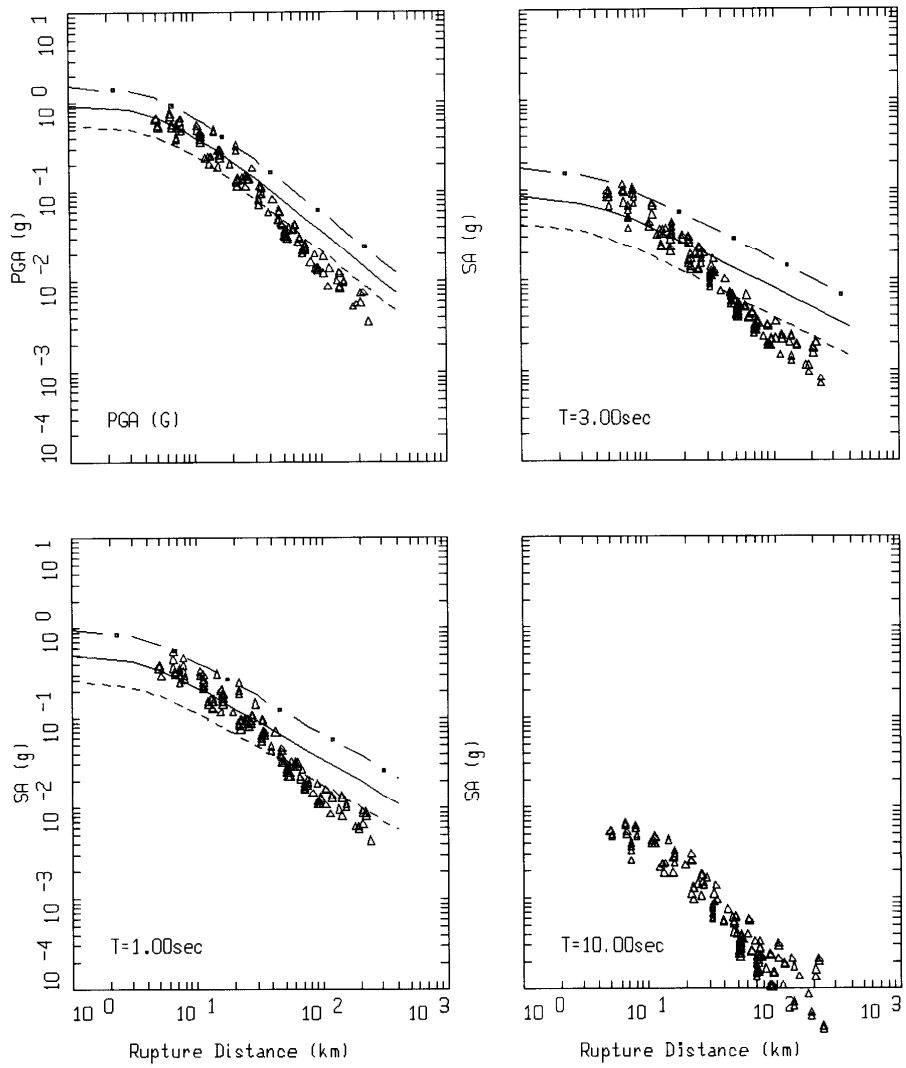
LEGEND

△ △	PEER SIMULATIONS, CASE RB, T=1.00 SEC
—— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RB
M=6.5, L=18km, W=18km, DIP=45, SHALLOW SLIP



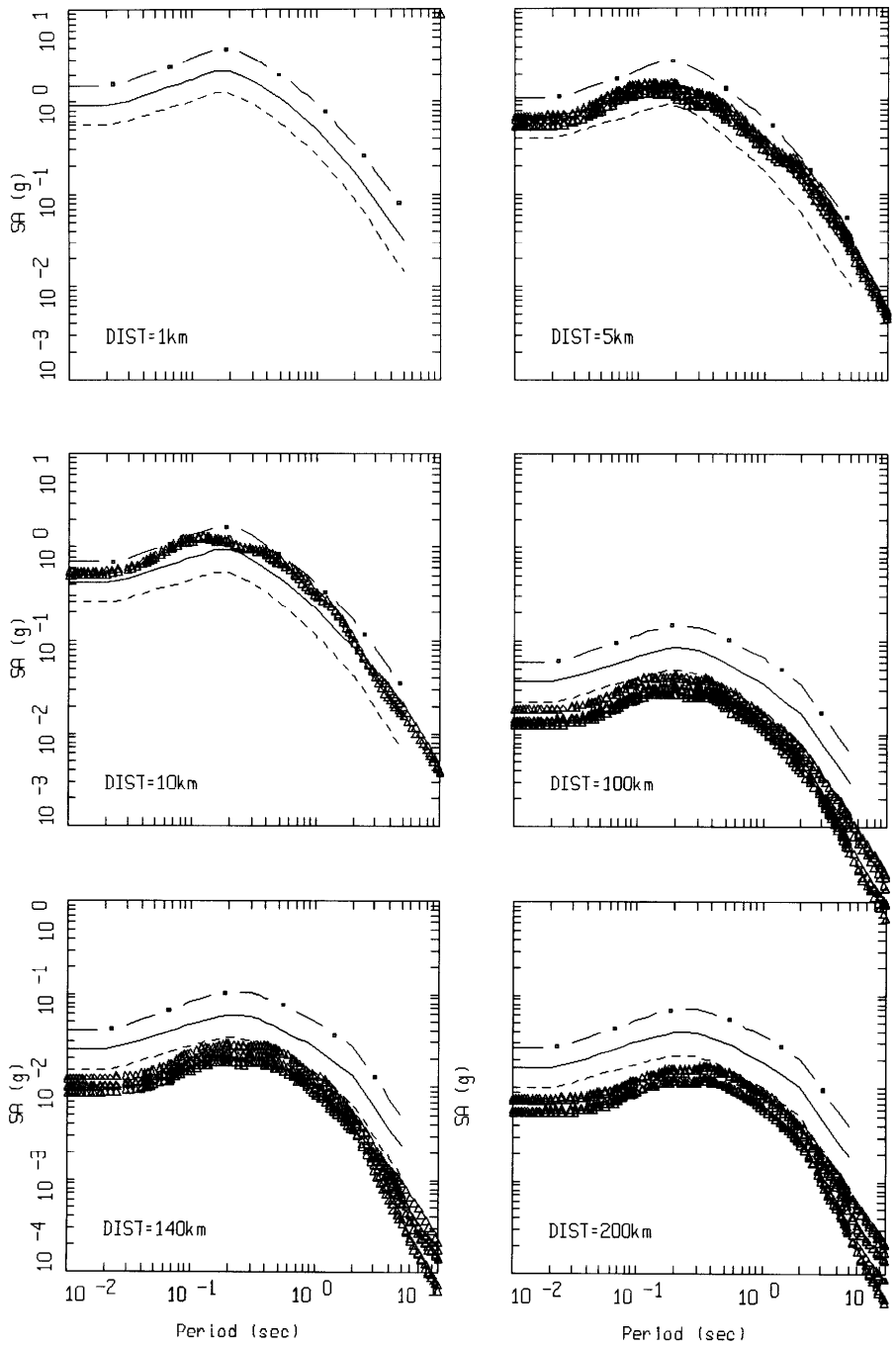
PEER NGA FINITE FAULT MODELING, CASE: RB
M=6.5, L=18km, W=18km, DIP=45, SHALLOW SLIP



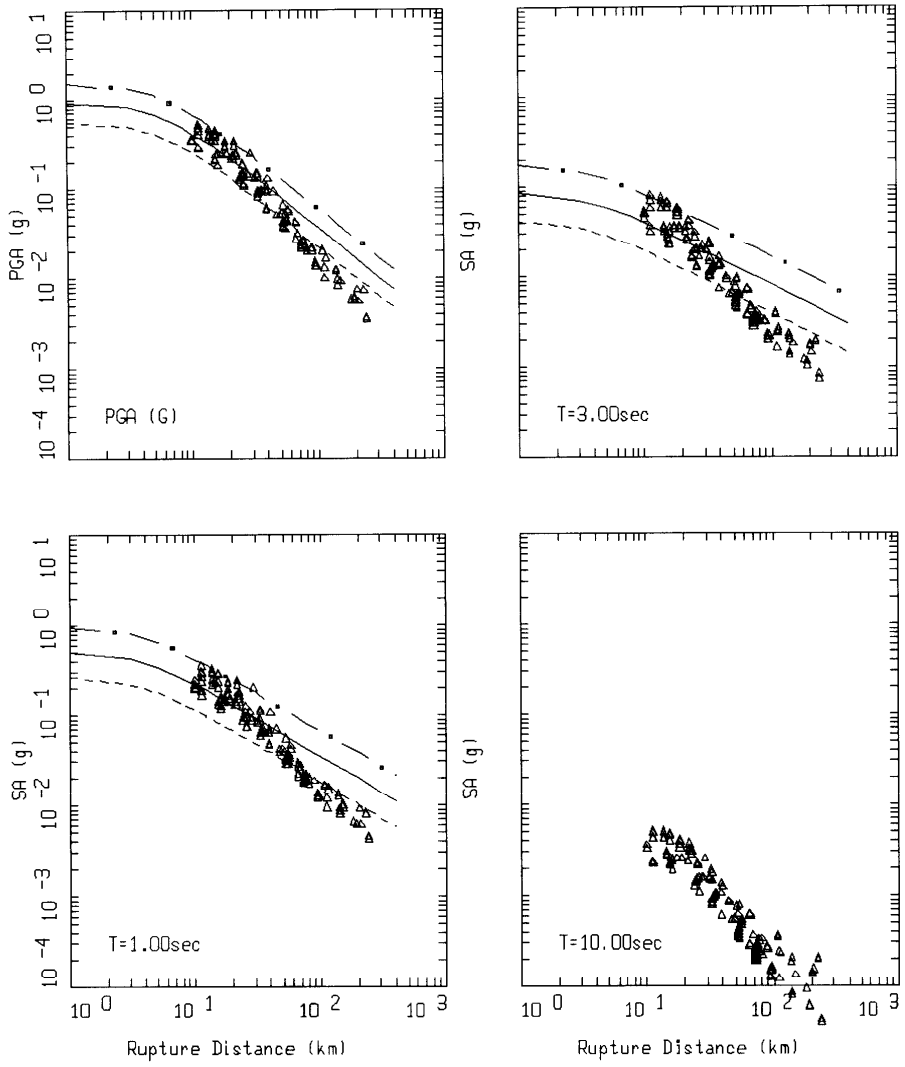
LEGEND

△ △	PEER SIMULATIONS, CASE RC, T=1.00 SEC
—— · ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
————	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RC
M=6.5, L=18km, W=18km, DIP=45, DEEP SLIP



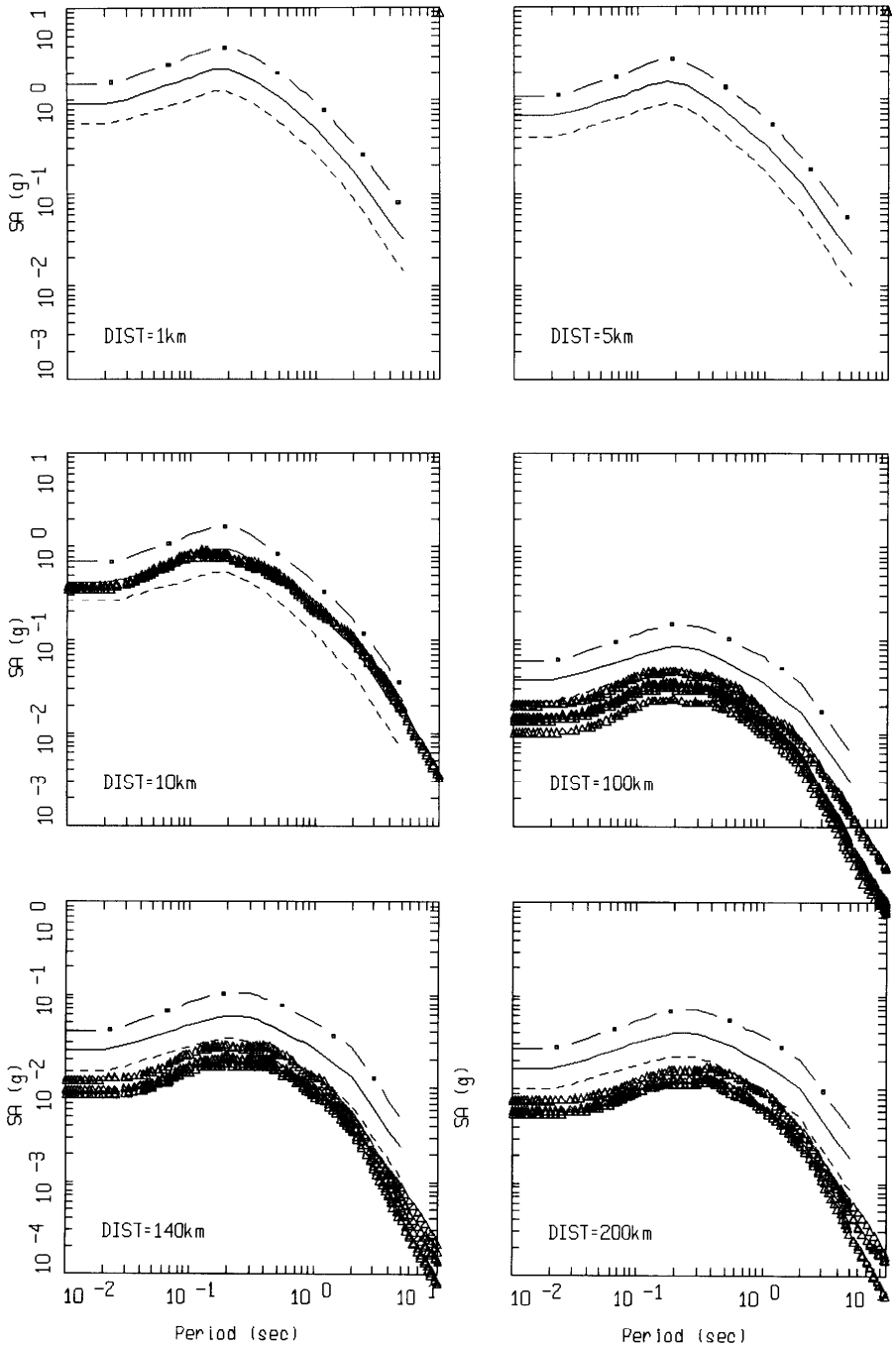
PEER NGA FINITE FAULT MODELING, CASE: RC
M=6.5, L=18km, W=18km, DIP=45, DEEP SLIP



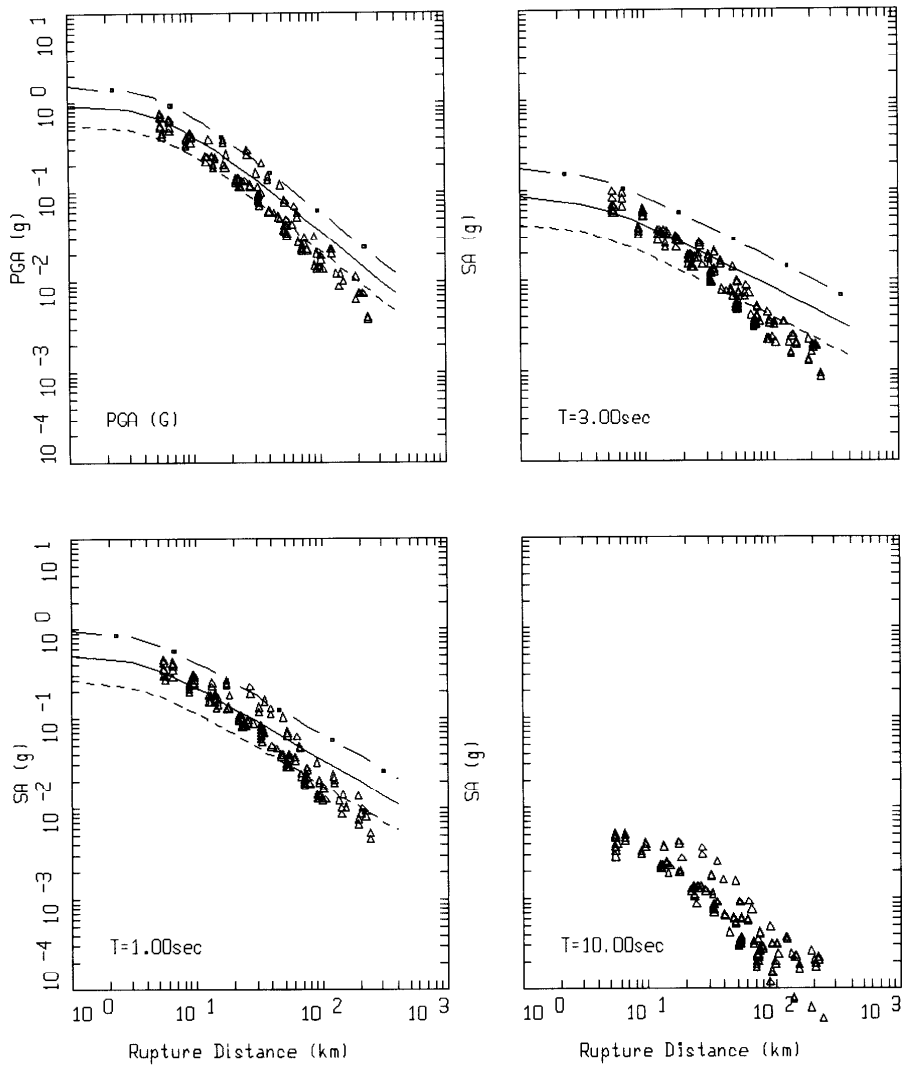
LEGEND

△ △	PEER SIMULATIONS, CASE RD, T=1.00 SEC
—— • ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
————	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RD
M=6.5, L=18km, W=18km, DIP=45, DEEP SLIP



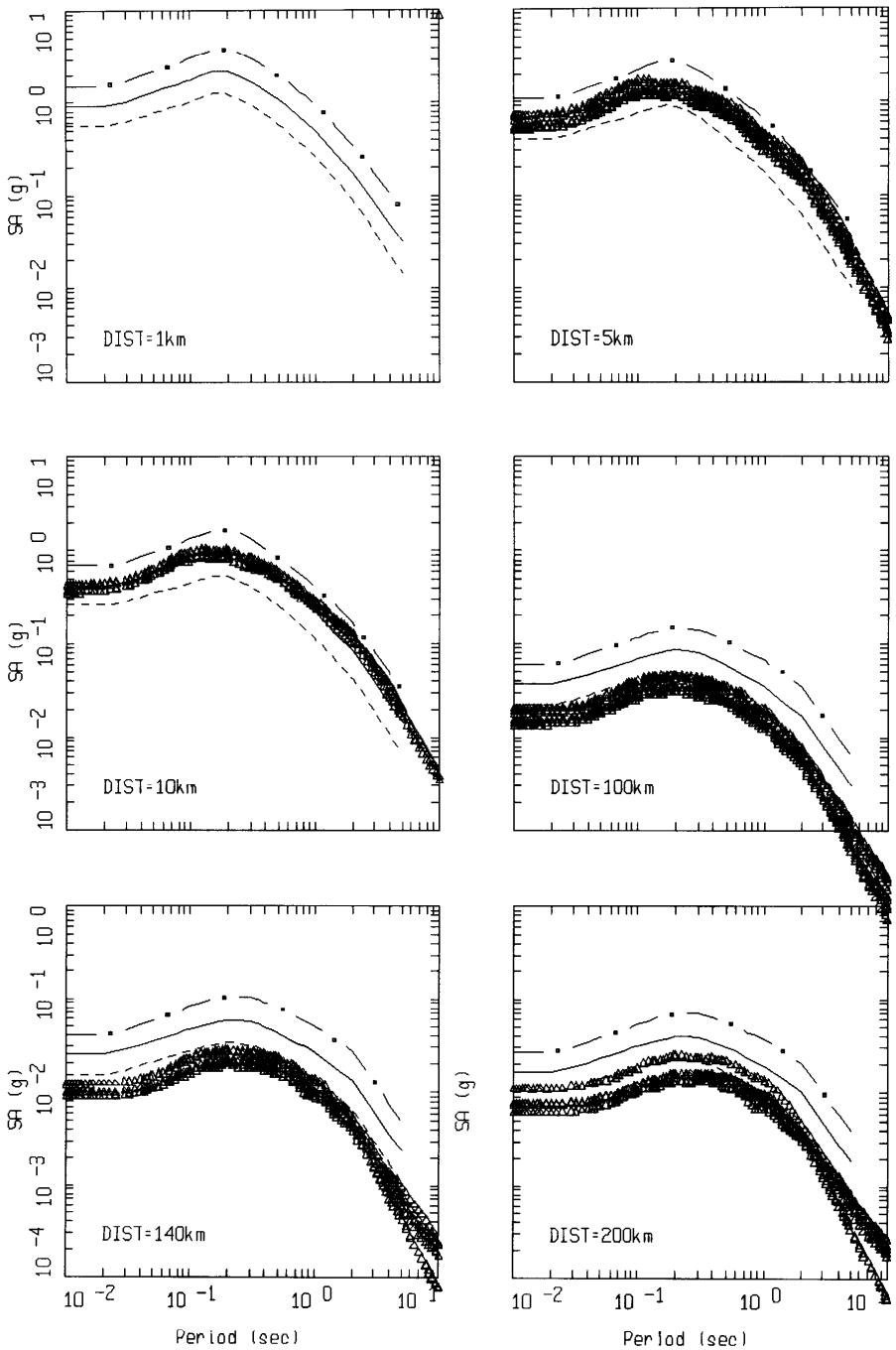
PEER NGA FINITE FAULT MODELING, CASE: RD
M=6.5, L=18km, W=18km, DIP=45, DEEP SLIP



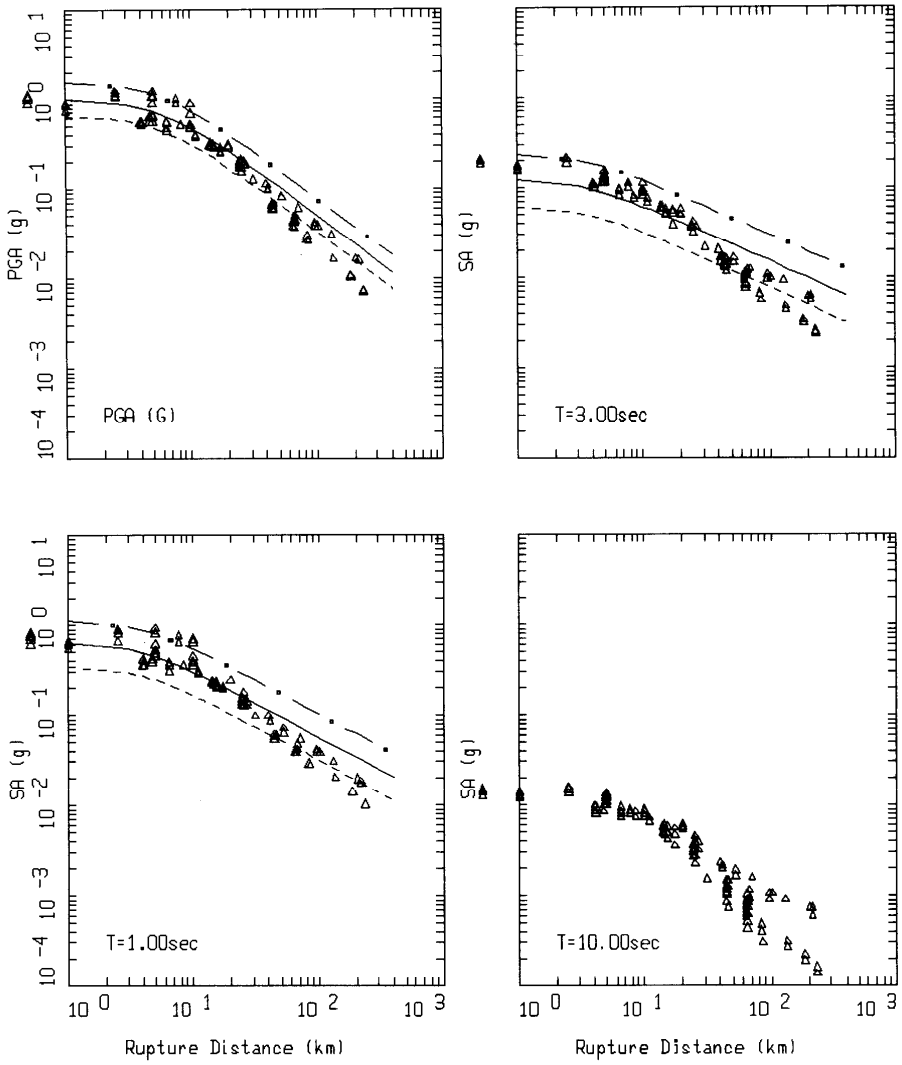
LEGEND

△ △	PEER SIMULATIONS, CASE RE, T=1.00 SEC
—— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RE
M=6.5, L=18km, W=18km, DIP=60, DEEP SLIP



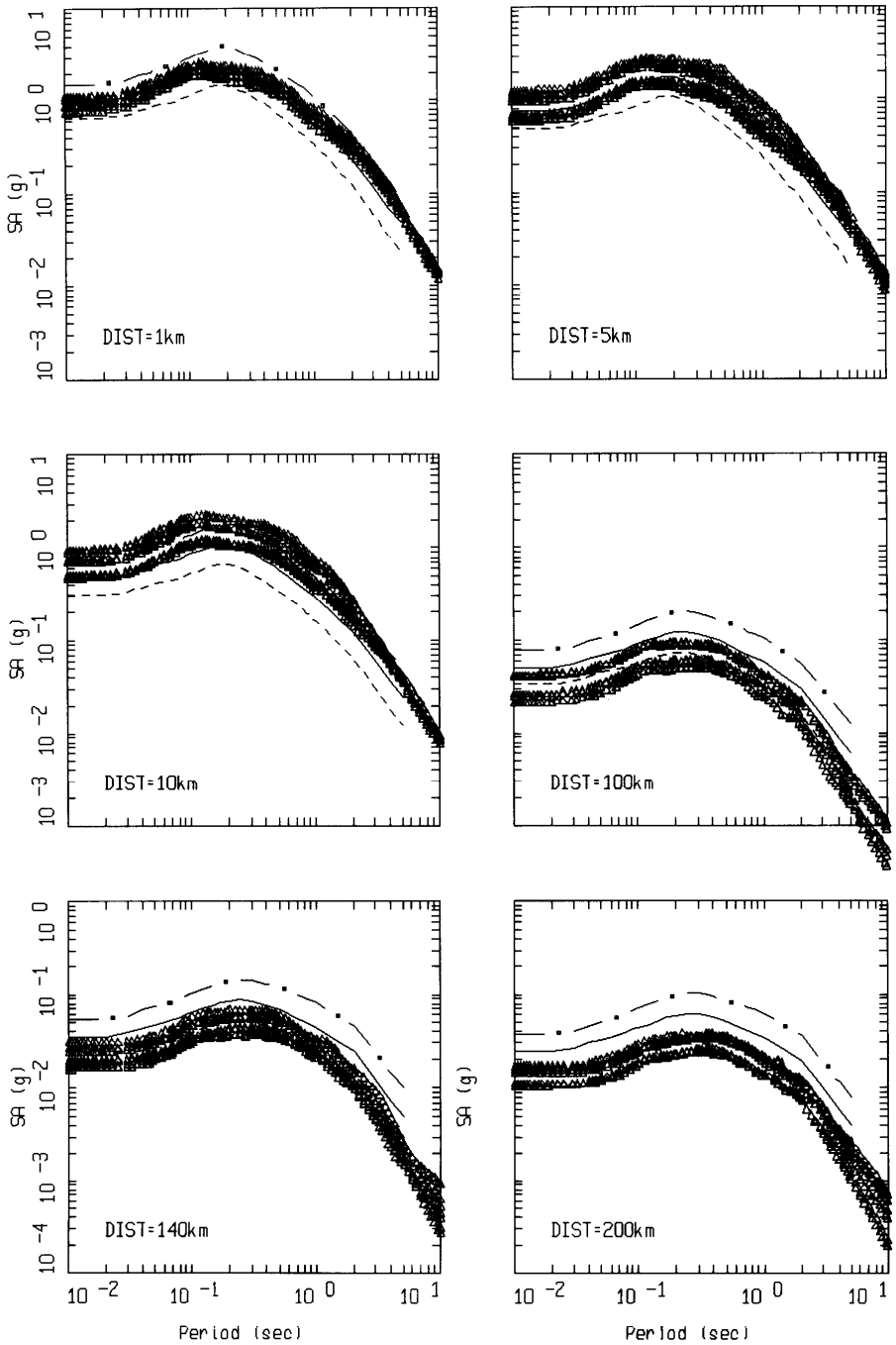
PEER NGA FINITE FAULT MODELING, CASE: RE
M=6.5, L=18km, W=18km, DIP=60, DEEP SLIP



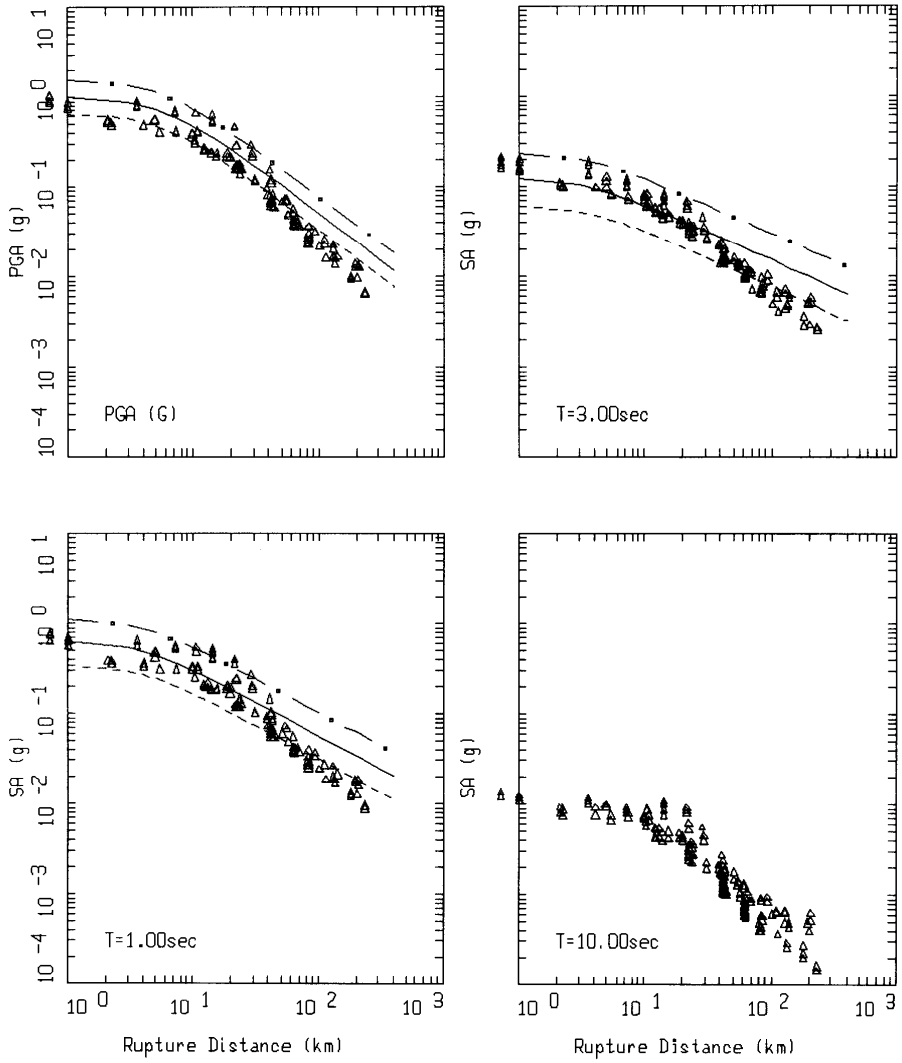
LEGEND

△ △	PEER SIMULATIONS, CASE RF, T=1.00 SEC
—— · ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
————	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RF
M=7.0, L=32km, W=32km, DIP=30, DEEP SLIP



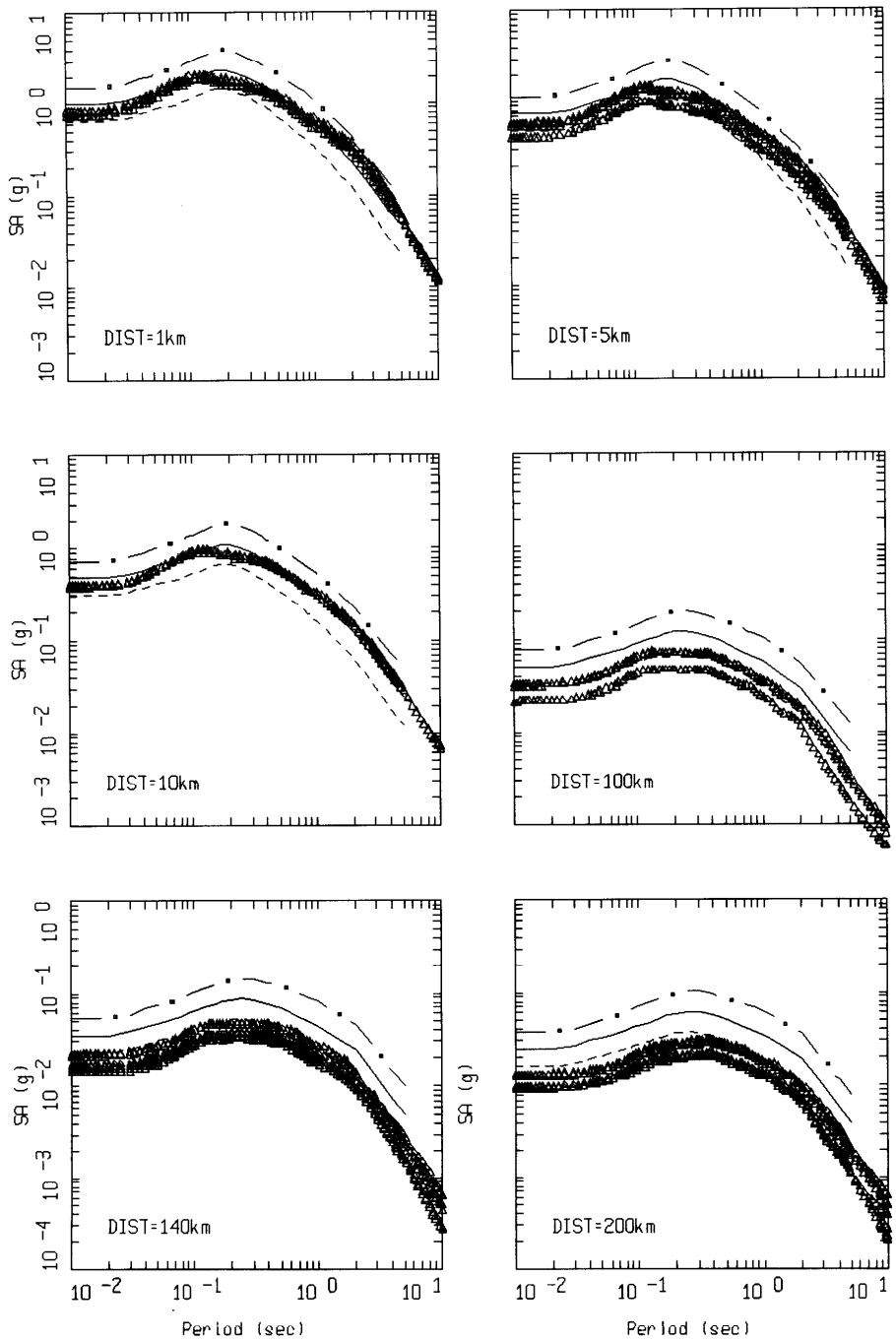
PEER NGA FINITE FAULT MODELING, CASE: RF
M=7.0, L=32km, W=32km, DIP=30, DEEP SLIP



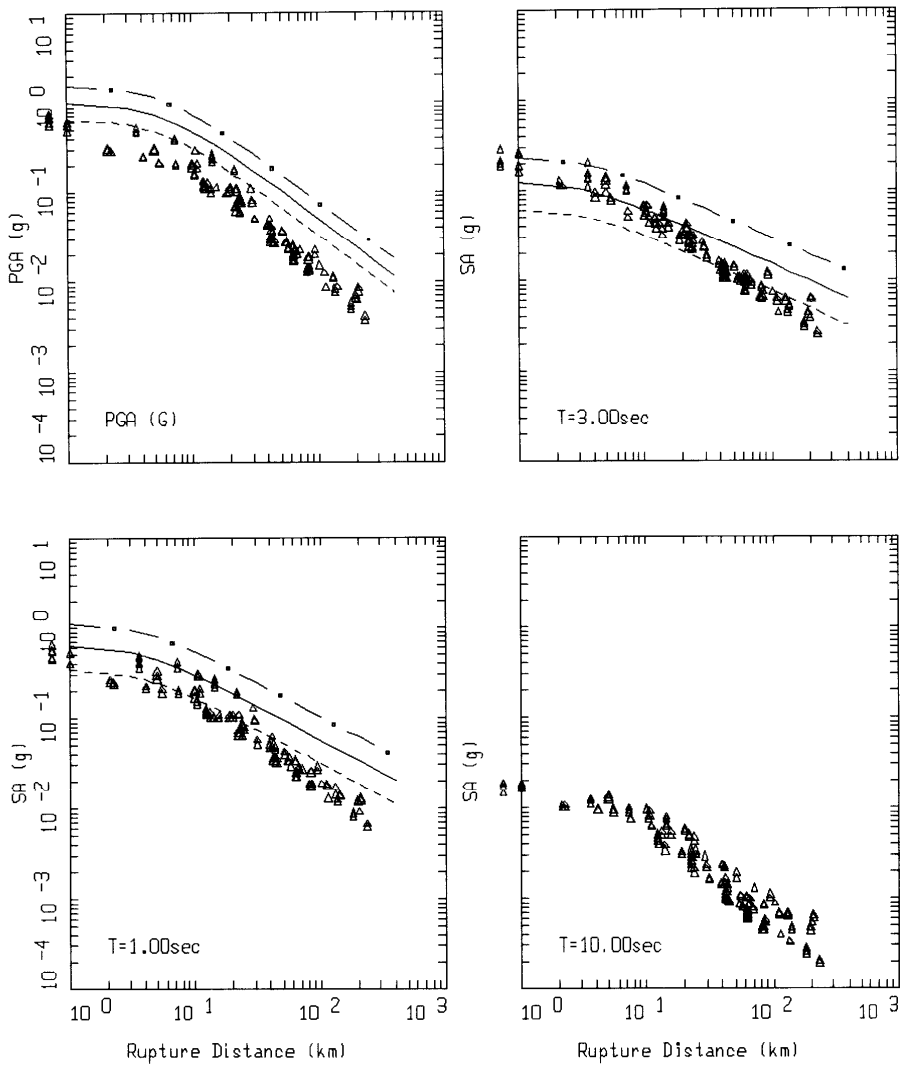
LEGEND

△ △	PEER SIMULATIONS, CASE RG, T=1.00 SEC
— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RG
M=7.0, L=36km, W=28km, DIP=45, DEEP SLIP



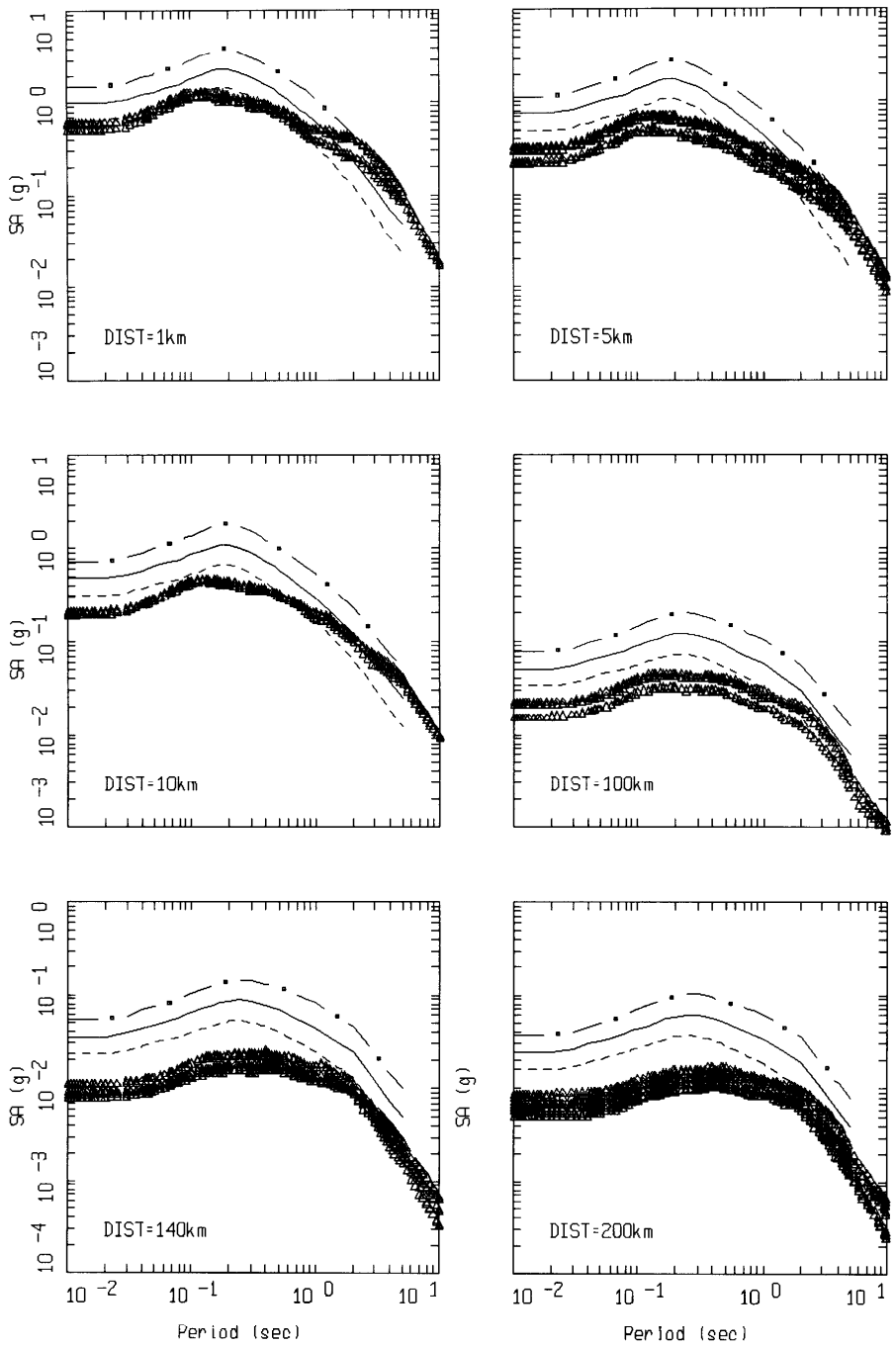
PEER NGA FINITE FAULT MODELING, CASE: RG
M=7.0, L=36km, W=28km, DIP=45, DEEP SLIP



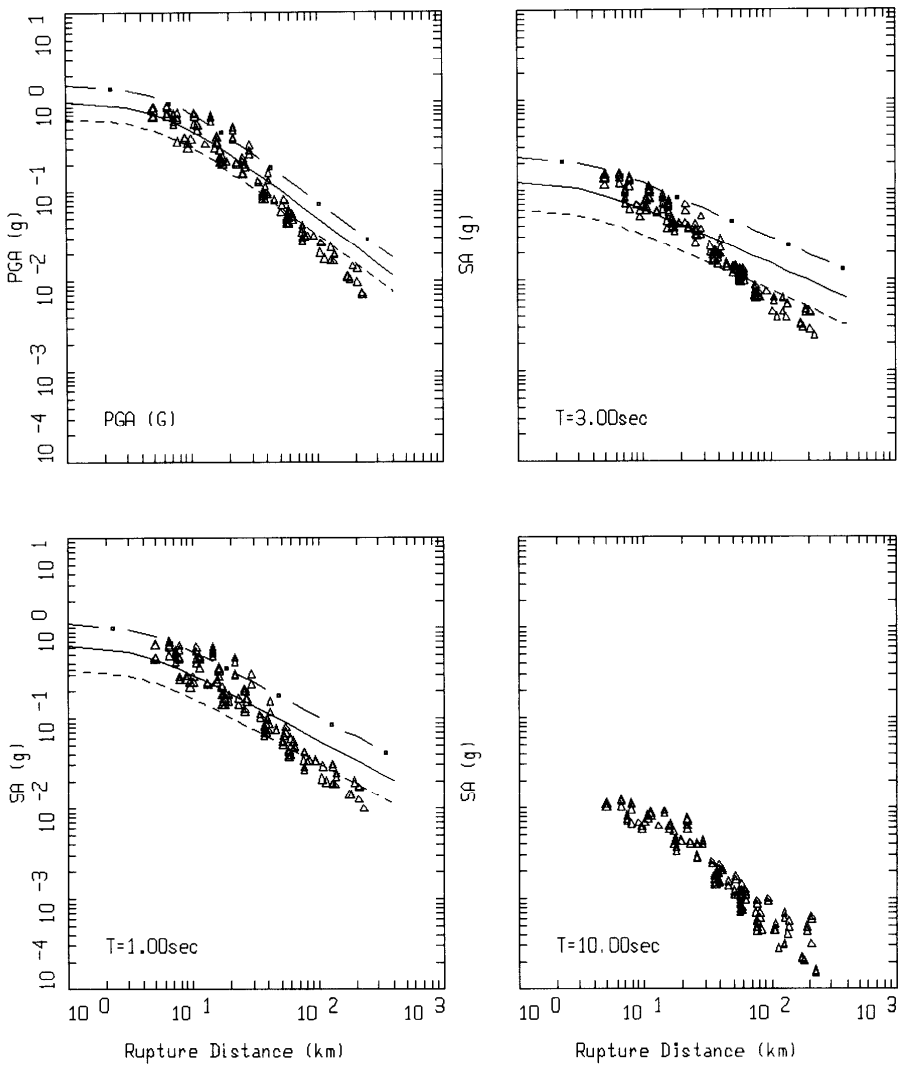
LEGEND

△ △	PEER SIMULATIONS, CASE RG, T=1.00 SEC
—— · ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
————	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RG
M=7.0, L=36km, W=28km, DIP=45, SHALLOW SLIP



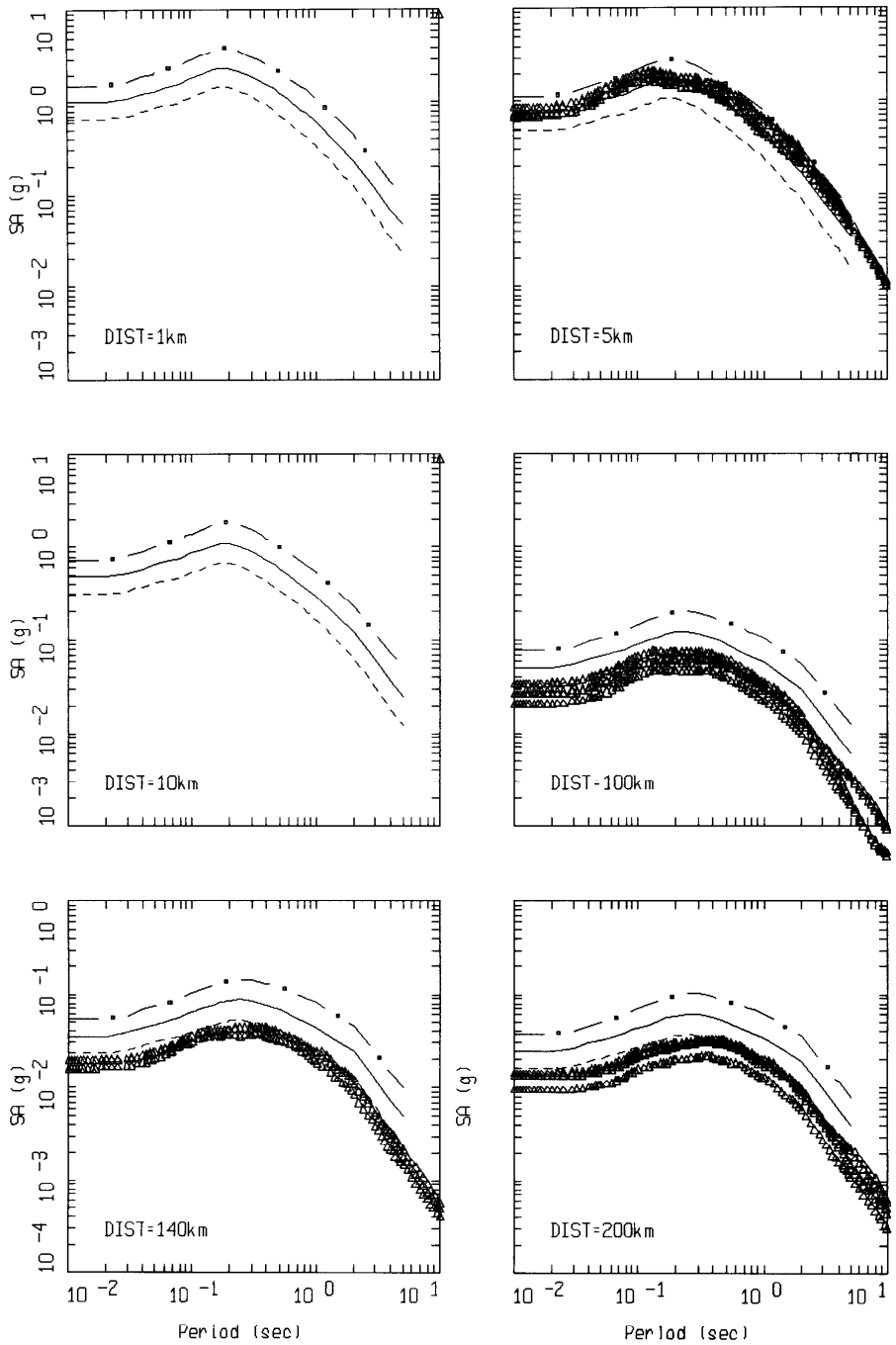
PEER NGA FINITE FAULT MODELING, CASE: RG
M=7.0, L=36km, W=28km, DIP=45, SHALLOW SLIP



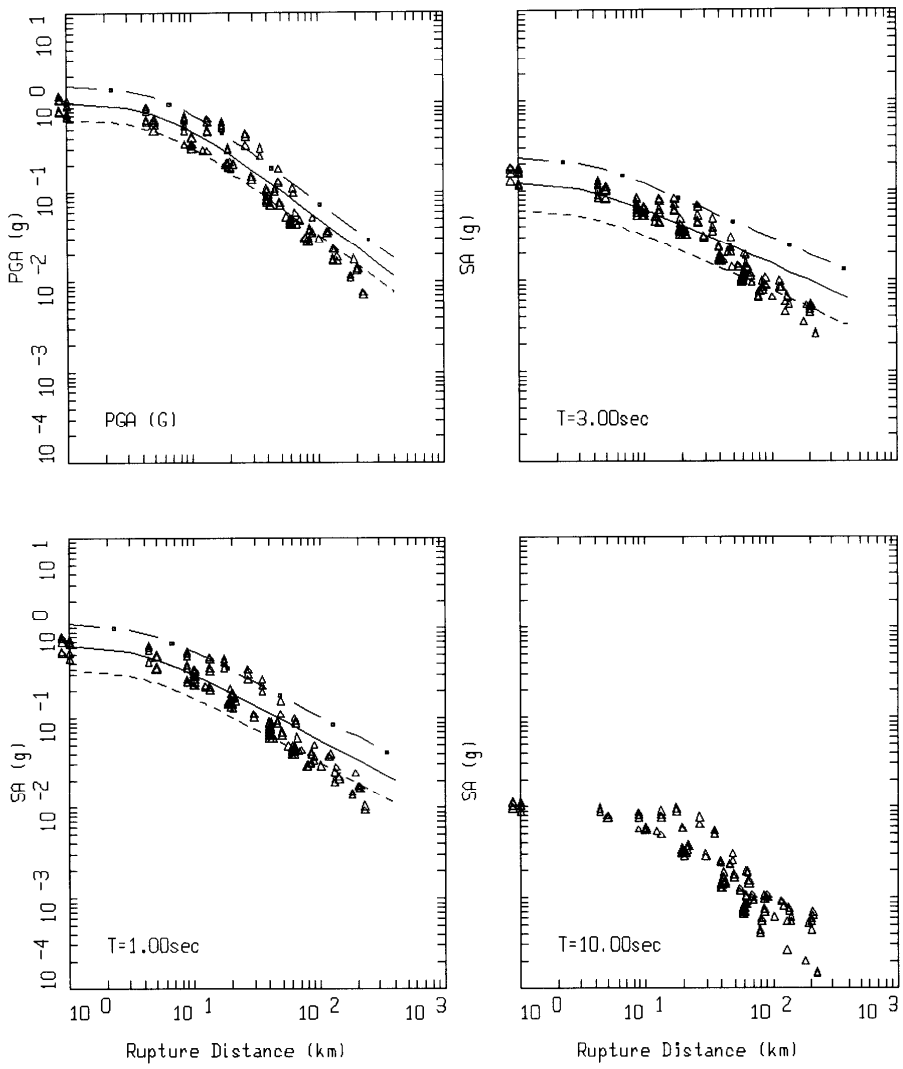
LEGEND

△ △	PEER SIMULATIONS, CASE RH, T=1.00 SEC
— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RH
M=7.0, L=48km, W=21km, DIP=45, DEEP SLIP



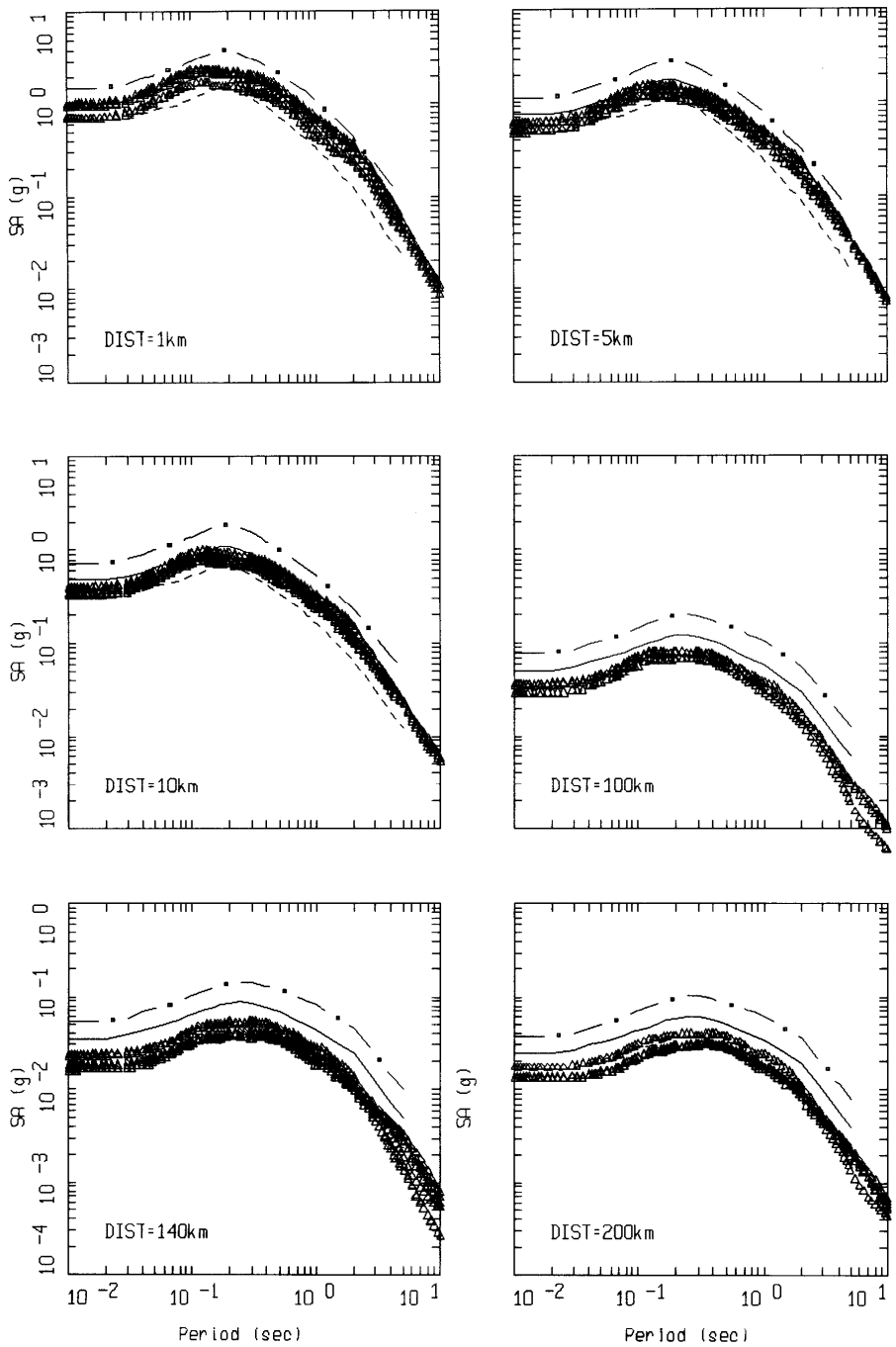
PEER NGA FINITE FAULT MODELING, CASE: RH
M=7.0, L=48km, W=21km, DIP=45, DEEP SLIP



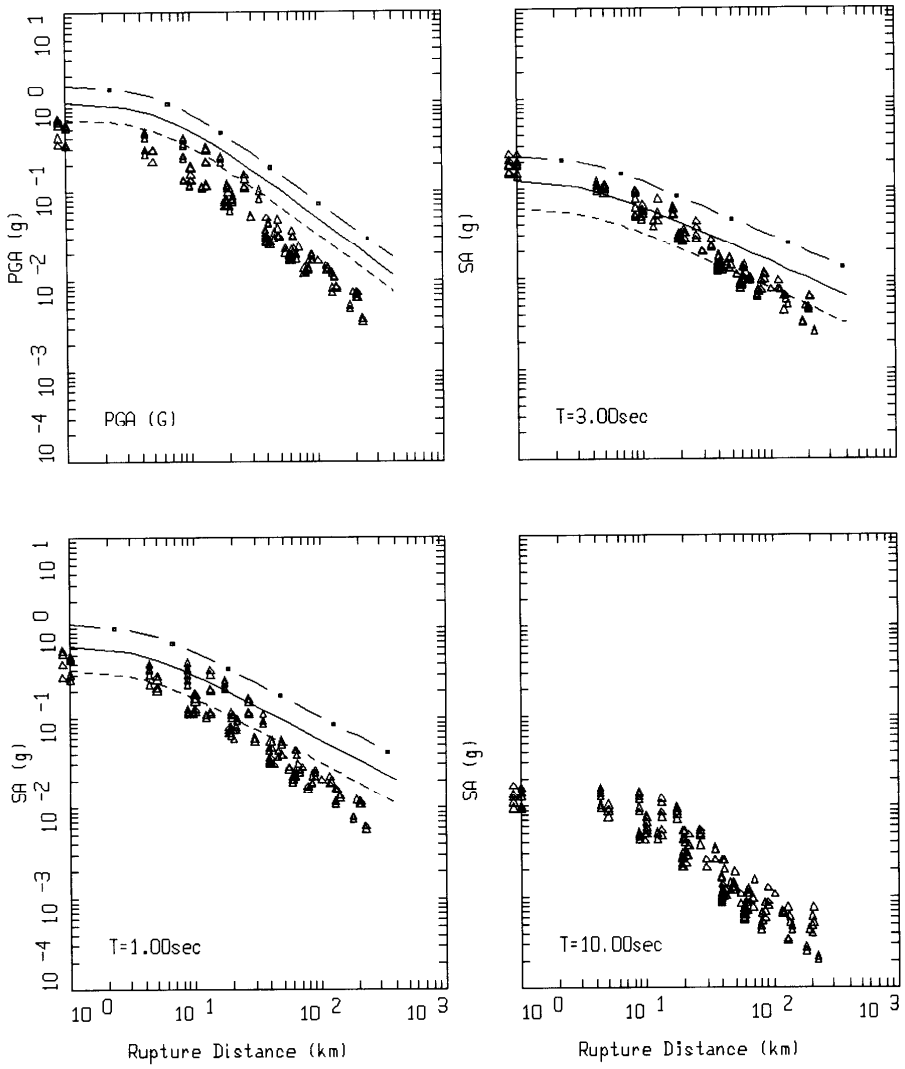
LEGEND

△ △	PEER SIMULATIONS, CASE RI, T=1.00 SEC
—— • ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RI
M=7.0, L=43km, W=23km, DIP=60, DEEP SLIP



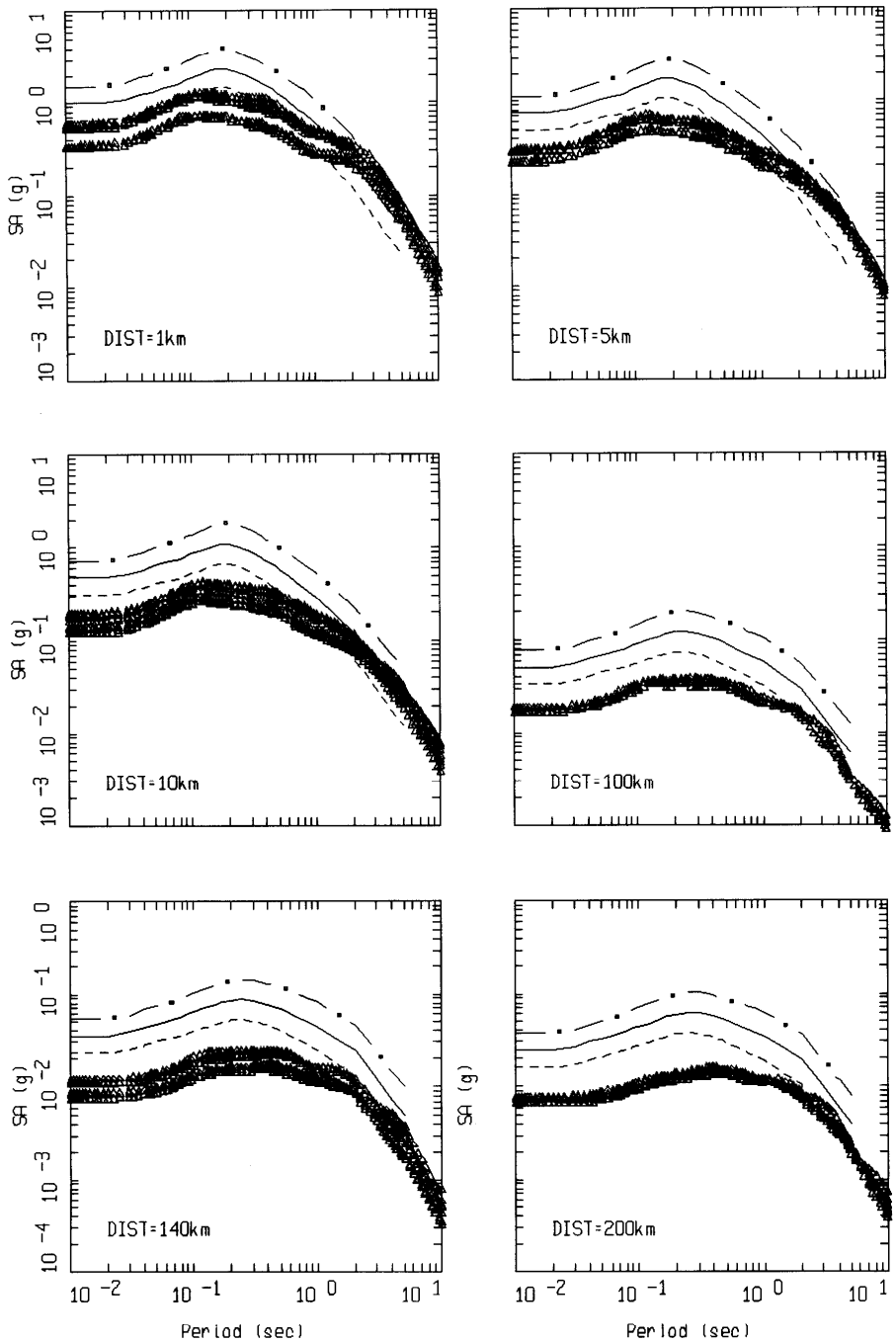
PEER NGA FINITE FAULT MODELING, CASE: RI
M=7.0, L=43km, W=23km, DIP=60, DEEP SLIP



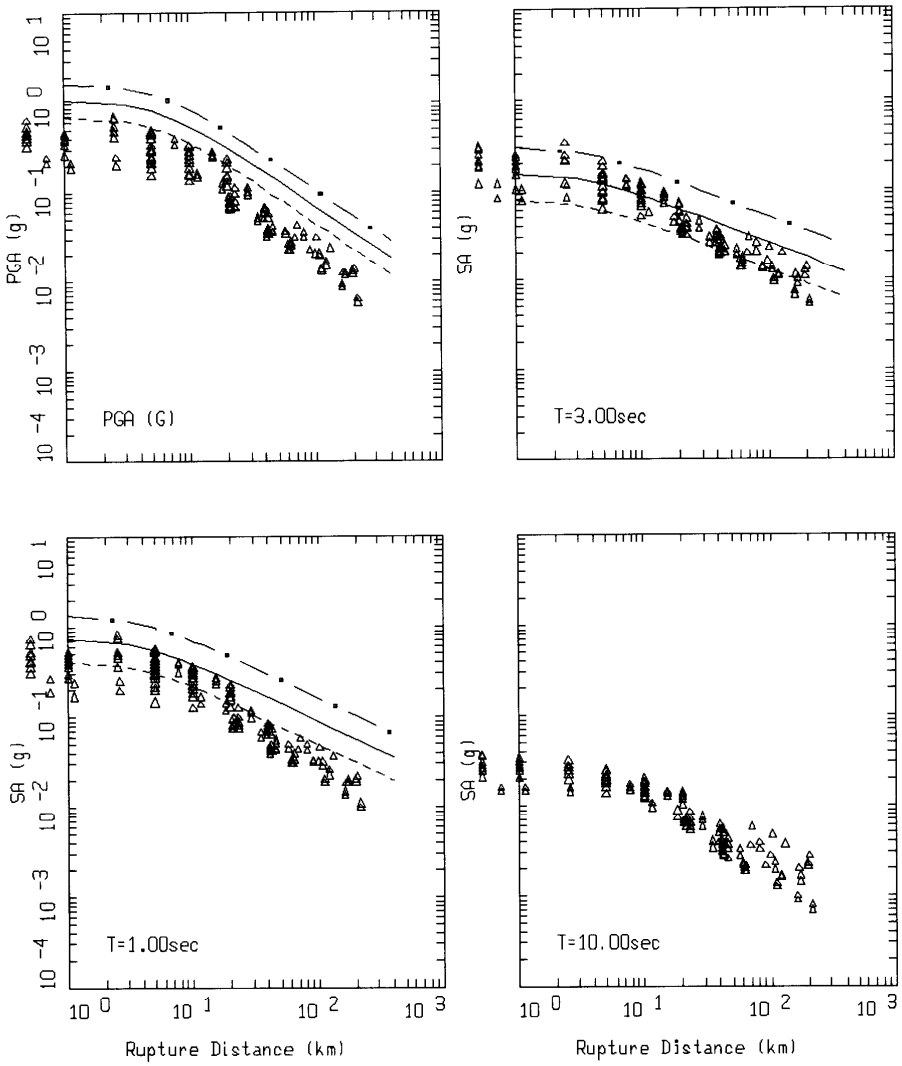
LEGEND

△ △	PEER SIMULATIONS, CASE RI, T=1.00 SEC
— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RI
M=7.0, L=43km, W=23km, DIP=60, SHALLOW SLIP



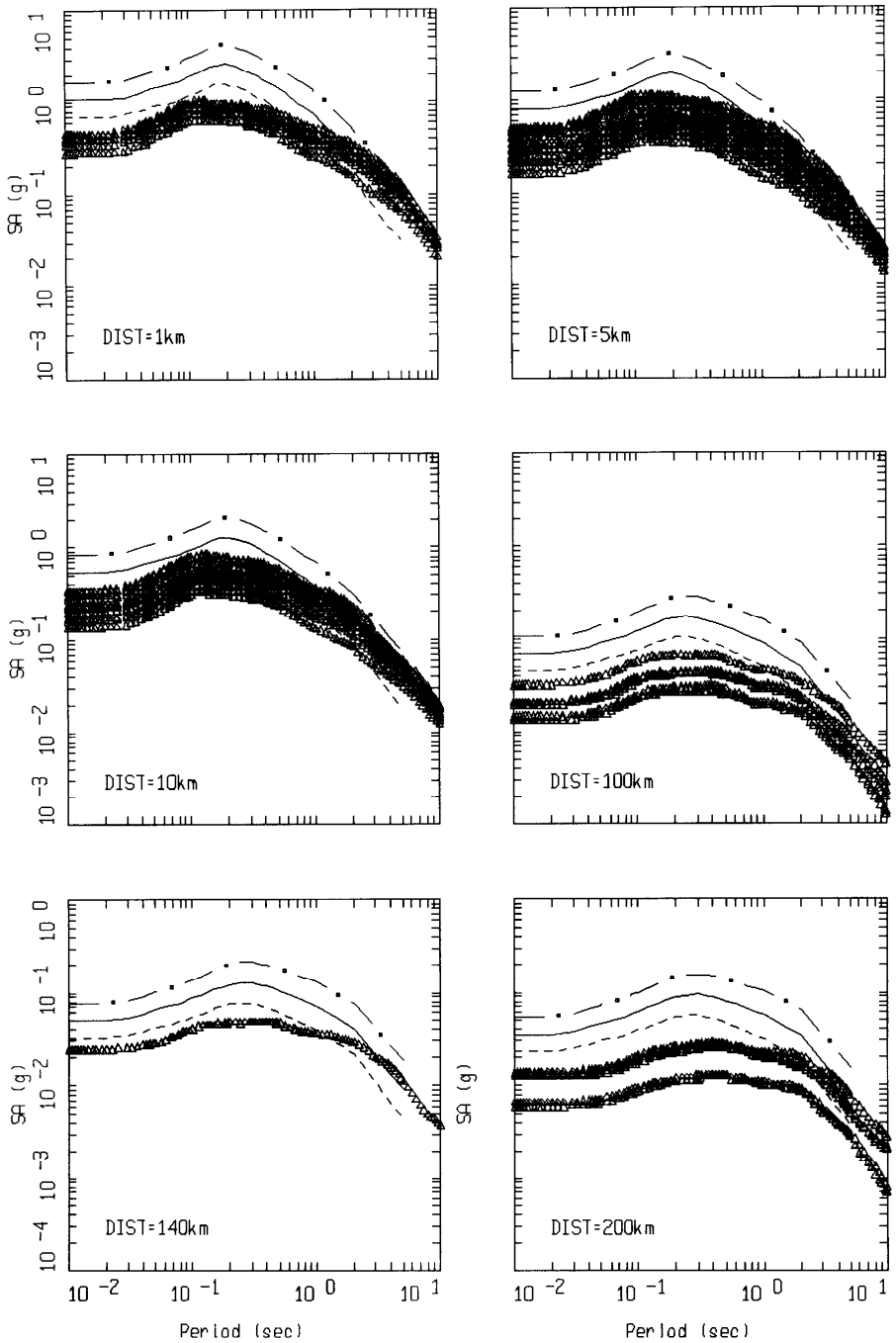
PEER NGA FINITE FAULT MODELING, CASE: RI
M=7.0, L=43km, W=23km, DIP=60, SHALLOW SLIP



LEGEND

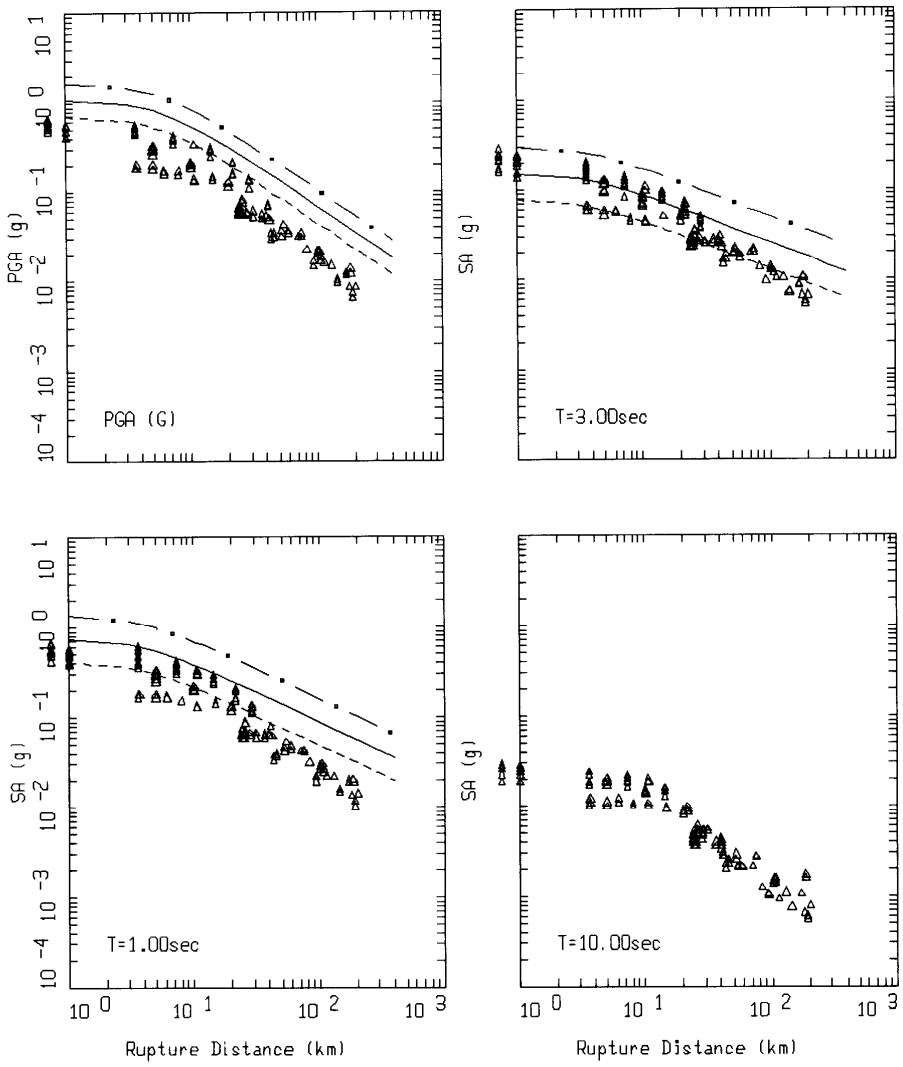
△ △	PEER SIMULATIONS, CASE RJ, T=1.00 SEC
— · —	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
———	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RJ
M=7.5, L=79km, W=40km, DIP=30



PEER NGA FINITE FAULT MODELING, CASE: RJ

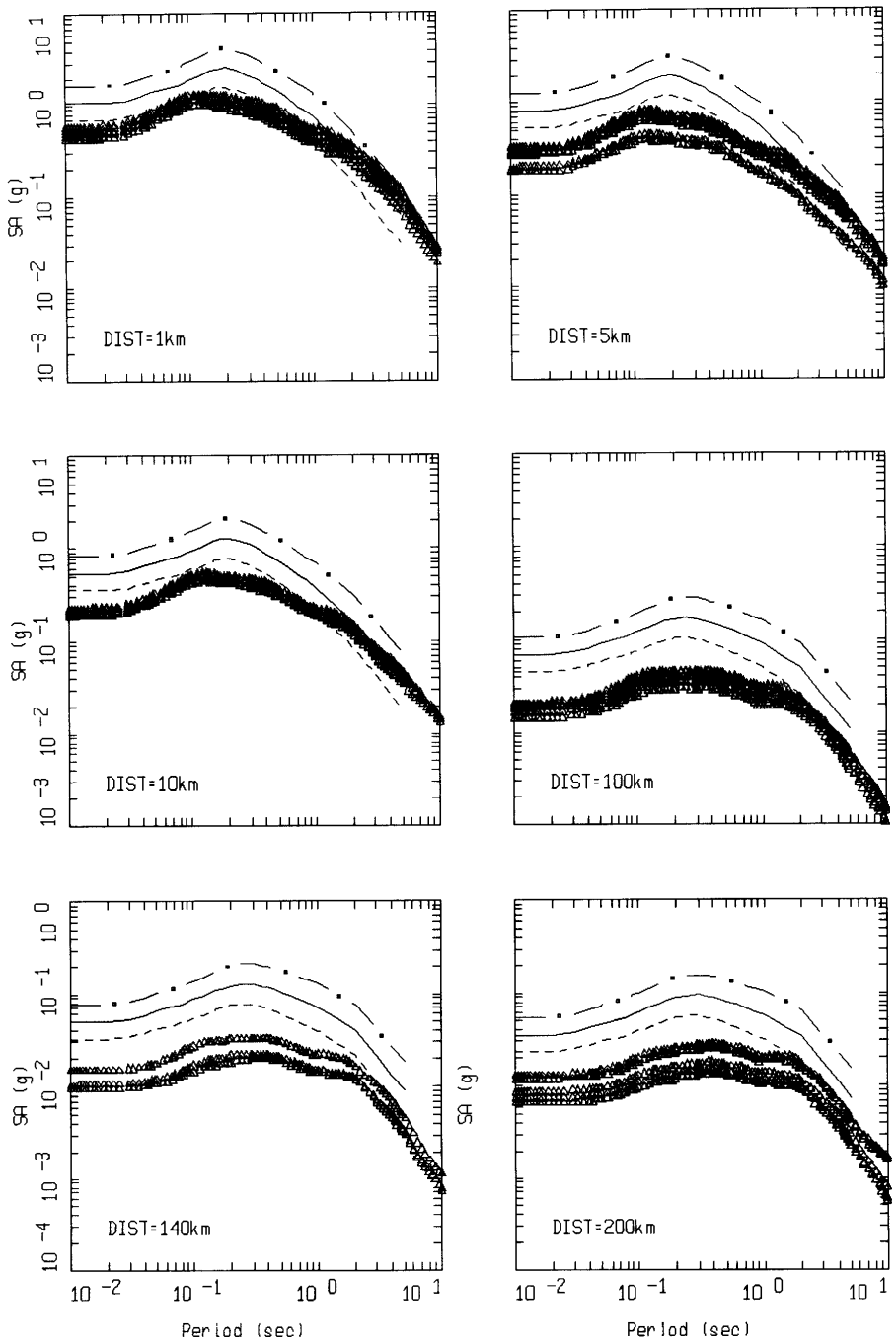
M=7.5, L=79km, W=40km, DIP=30



LEGEND

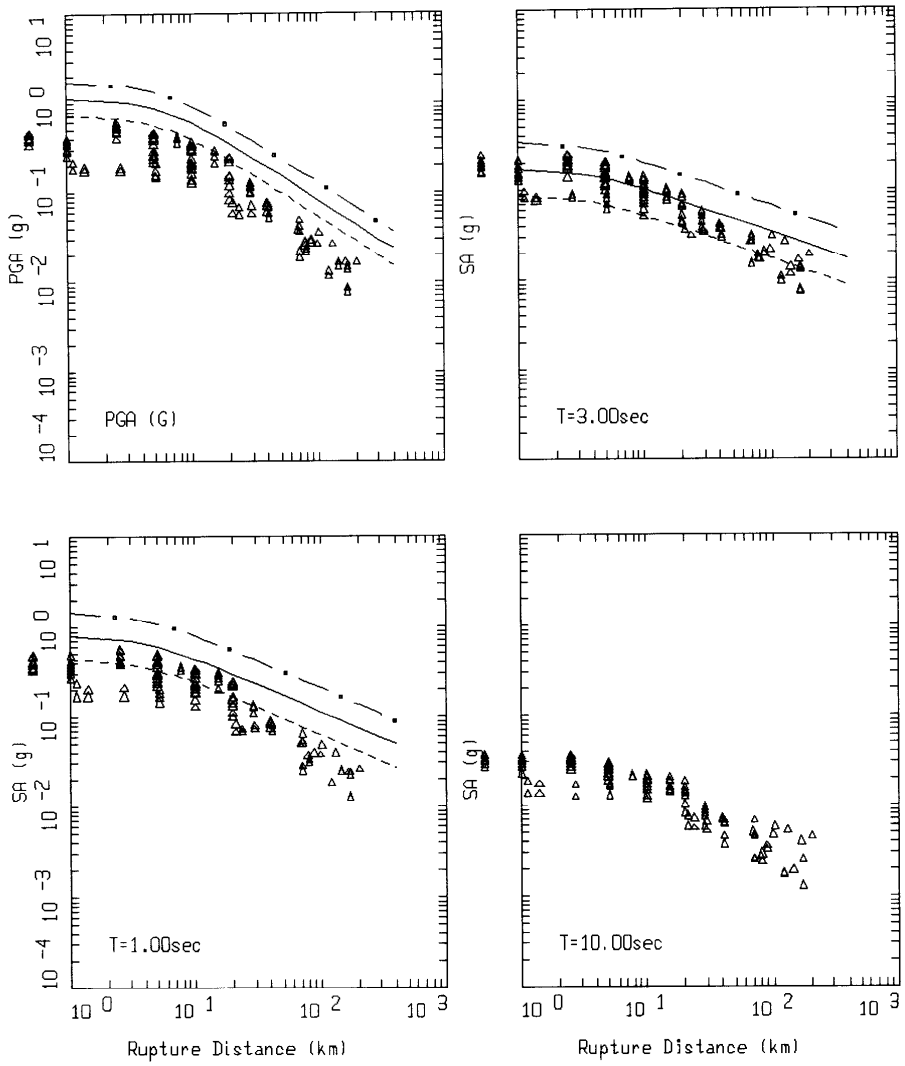
△ △	PEER SIMULATIONS, CASE RK, T=1.00 SEC
—— • ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
————	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RK
M=7.5, L=113km, W=28km, DIP=30



PEER NGA FINITE FAULT MODELING, CASE: RK

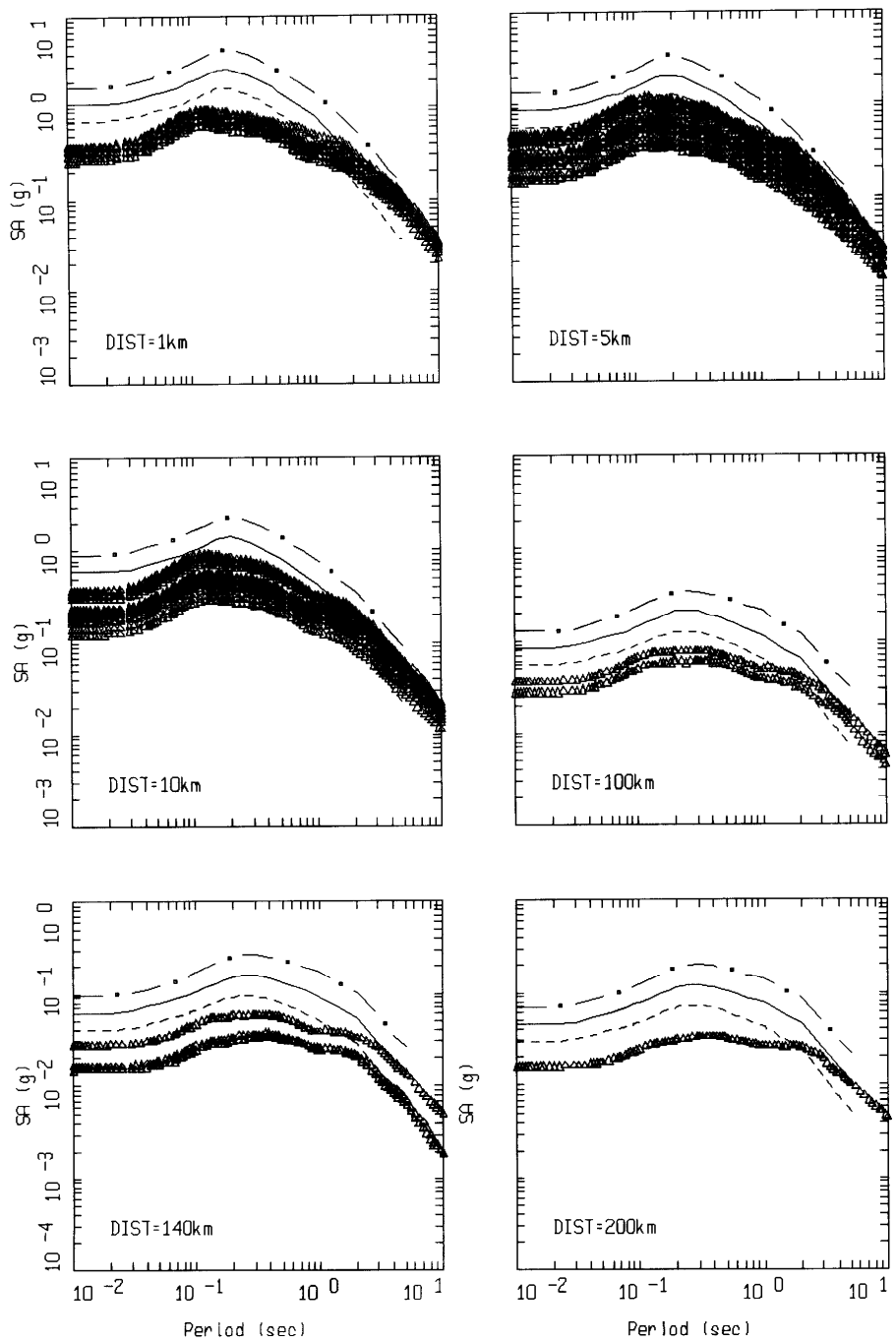
M=7.5, L=113km, W=28km, DIP=45



LEGEND

△ △	PEER SIMULATIONS, CASE RL, T=1.00 SEC
—— • ——	ABRAHAMSON AND SILVA (1997): 84TH PERCENTILE
————	ABRAHAMSON AND SILVA (1997): 50TH PERCENTILE
- - - - -	ABRAHAMSON AND SILVA (1997): 16TH PERCENTILE

PEER NGA FINITE FAULT MODELING, CASE: RL
M=7.8, L=158km, W=40km, DIP=30



PEER NGA FINITE FAULT MODELING, CASE: RL

M=7.8, L=158km, W=40km, DIP=30