5 Seismological Data and Analysis

A seismic hazard analysis requires, as explained earlier, a thorough analysis of earthquake recurrence characteristics. In order to do so, an adequate earthquake catalog containing more than 3756 events since 1505 ($M_W \geq 3.5$), between 12 -19°N and 93-87°W, has been compiled. The many sources of information used here include the PAIGH (Panamerican Institute of Geography and History) historical catalog and the INSIVUMEH data base for 1977-1994 (Molina and Villagrán (1990), as well as data from the regional compilation of Rojas et al. (1993a;b). It is important to note here that the analysis essentially was based only on data from the 20th century, while information before 1900 were used only to test the models. See Appendix I (2593 events ($M_W \geq 4.5$).

5.1 Seismicity Distribution

The tectonic setting of Central America as described above indicates that the seismic activity is distributed not only at crustal depths but also deeper due to the collision between the oceanic and continental crusts which generates stresses in both and in the down going slab. For this study purpose, the seismicity in Guatemala has been divided in three different populations with respect to focal depth, a shallow one down to 50 km, an intermediate one between 50 and 125 km, and a deep source below 125 km. See Figs. 5.1 and 5.2.

5.2 Magnitude Relations

Central America is a very active seismic region, and Guatemala has in particular a history of large destructive earthquakes. This suggest that magnitude must be standarized in a way that the whole experienced event sizes can be covered For this reason the moment magnitude, hereafter called M_W established by Hanks and Kanamori (1979) is employed. The expressions

$$M_W = \frac{2}{3}(\log M_0) - 10.7 \quad (5.2)$$

and

$$M_0 = \mu A D \quad (5.3)$$

which in turn provides a connection to the seismic energy E_S,

$$E_S = \frac{\Delta\sigma}{2\mu} M_0 \quad (5.4)$$

where M_W is the moment magnitude, M_0 is the seismic moment expressed in dyne-cm, μ

is the shear (rigidity) modulus, A is the fault area, D the average displacement across the fault and $\Delta\sigma$ is the stress drop.

Other magnitude scales experience, for different reasons, bias problems. The body wave magnitude m_b has problems both below 4.5 and above 6.0, the local magnitudes M_L and M_D have problems often above 5.0-5.5, and the surface waves magnitude M_S starts to saturate around 6.5. Even if the M_S scale has less bias problems than the others there is an additional problem in this case because of its sensitivity with respect to depth. M_W has been widely used during the last decade, and an important additional reason for using it here is that this is the magnitude scale used in developing the strong motion attenuation model (used in this work) developed for Central America by Climent et al. (1994).

Since M_W up to now is available routinely only for a small subset of the events (mostly those with Harvard moment tensor solutions) it has been necessary to established the magnitudes indirectly for other events using the following procedure (cf. Rojas et al. 1993b; Camacho et al. 1994; Laporte et al. 1994):

- M_W was derived directly from M_0, whenever possible (Harvard solutions)
- When M_0 was not available M_W was derived from M_S, whenever possible
- When M_S was not available it was derived from m_b, whenever possible
- When m_b was not available it was derived from M_L, whenever possible
- When M_L was not available it was from M_D, whenever possible

The magnitude relationships used here are, for M_W vs. M_S:

$$M_W = 2.251 + 0.655M_S \tag{5.5}$$

which was derived specifically for Central American earthquakes by Rojas et al. (1993c), based on a linear orthogonal regression between Harvard CMT (Centroid Moment Tensor) seismic moments and M_S magnitude for 199 reports ranging up to 6.6. For data above this limit M_W=M_S as found by Ekstrom and Dziewonski (1988) using a much larger database. For M_S vs. m_b, a regression by Rojas et al. (1993b) using 590 events gives

$$M_S = 2.00m_b - 5.28 \tag{5.6}$$

For m_b vs. M_L, Rojas et al. (1993b), using 823 events, gets

$$m_b = 0.83M_L + 0.81 \tag{5.7}$$

For M_L vs. M_D. Villagrán (1994) derived a relation based on a regression of local magnitudes up to 5.0, based on more than 100 events recorded by digital accelerometers in Central America (1993-94). The relation reads

$$M_L = 1.163 M_D - 0.52 \quad (5.8)$$

M_D is the most common local magnitude used in Central America.

5.3 Foreshocks and Aftershocks

The assumption used in a probabilistic hazard analysis of earthquakes being Poissonian distributed is not consistent with the occurrence of foreshocks and aftershocks, and these therefore have to be eliminated from the catalog. The clusters were identified in this case by using a graphical technique based on the time-distance characteristics of the events in the catalog. Before removing any event, a visual inspection based on experience in seismicity of the region is still necessary. Fig. 5.3 shows the clustering and Table 5.1 a foreshock-aftershock sequence.

5.4 Earthquake Catalog Completeness

The recurrence parameters describing the seismic activity levels within the source zones used in a probabilistic earthquake hazard analysis are normally, given the essential assumption on a Poisson distribution, estimated from an earthquake catalog that spans a time period long enough to secure stability but short enough to secure completeness. Different approaches for such completeness analyses are available, in this study we have used one of the most robust ones, namely to review the distribution of magnitudes as a function of time shown in Fig. 5.4.

From Fig. 5.4 it can be concluded that the catalog for Guatemala seems to be

- reasonably complete since 1900 for magnitudes above M_W 5.7, and
- reasonably complete since 1963 for magnitudes above M_W 4.3.

5.5 Earthquake Recurrence

The frequency-magnitude (Gutenberg-Richter) cumulative relation can be in testing the catalog homogeneity as well as for estimating earthquake recurrence parameters.

In the present case, three different population of earthquakes have been evaluated, including shallow, intermediate and deeper events. Three different time-intervals were evaluated by setting the lower bound magnitude to be consistent with the different completeness thresholds. The time periods used have been:

- 1900-1994 (95 years),
- 1963-1994 (32 years), coinciding with the WWSSN network, and
- 1977-1994 (18 years), coinciding with the Guatemalan network.

Fig. 5.5 show the final results here.

5.6 Intensity

When quantifying seismicity it is common to make use of both earthquake magnitude and intensity. In fact, intensity has a more direct relation to engineering significance (damage) than magnitude, and can therefore also more directly be related to PGA (Peak Ground Acceleration). Intensity is based on effects caused to human infrastructure, while some relations also have been developed to implement ancient literature descriptions within the same interpretational framework.

We will here provide an approximated representation of the experienced intensities in Guatemala City during the present century.

Following Esteva and Rosenblueth (1964), PGA can be expressed as

$$PGA = b_1 e^{b_2 M} R^{-b_3} \tag{5.6.1}$$

where M is magnitude, R is the hypocentral distance, and b_1, b_2 and b_3 are the constants (2,000, 0.8, 2). A classical relation between PGA and intensity is due to Richter (1958):

$$\log(PGA) = \frac{I}{3} - \frac{1}{2} \tag{5.6.2}$$

where PGA is expressed in cm/s^2 (log base 10). To extrapolate values at different distances Ergin (1969) proposes

$$I_0 - I = n\log\left(\frac{R}{h}\right) \tag{5.6.3}$$

where I_0 is the intensity at the epicenter and n is either 3 or 5 depending on attenuation. For Guatemala a value n=5 has been chosen on basis that intensity attenuates relatively fast.

To test the applicability of these relations, a comparison between the observed and the calculated MMI was prepared using the present catalog (1900-94, $M_w \geq 5.0$) and also with more recent data (1984-94, $M_w \leq 5.0$) produced by INSIVUMEH. The last one for distances ranging between 30 and 125 km of focal distance. As seen in Fig. 5.6 the scatter is relative large, but still with some agreements with observed data.

The Fig. 5.7 shows an experimental interpretation of the magnitude in terms of intensity for Guatemala city (some of the values are real) since 1900 and table 5.2 summarize the number of observed and calculated intensities ($MMI \geq 2.0$) between 1984-94 (against INSIVUMEH's data).

Yr/Mo/Dy	Agen.	Hours	Lat.	Lon.	Depth	M_W	M_L	M_S
1979.11.26	GUA	214457.0	13.880	-90.890	25	4.2	4.1	3.1
1979.11.27	PDE	214324.9	13.778	-90.730	65	5.6	6.6	6.6
1979.11.27	ISC	214325.3	13.753	-90.755	70	5.6	6.6	6.6
1979.11.27	GUA	214321.0	13.580	-91.080	25	6.4	6.7	7.5
1979.11.27	GUA	214722.0	13.630	-91.020	25	4.8	4.8	4.3
1979.11.27	GUA	125352.0	13.420	-91.110	25	4.5	4.4	3.7

Table 5.1 A foreshock-aftershock identified sequence (main event highlighted).

Year	Observed	Computed	Ratio
1984	25	16	1.56
1985	23	46	0.50
1986	21	31	0.68
1987	27	26	1.04
1990	18	31	0.58
1993	15	39	0.39
1994	39	37	1.05

Table 5.2 Statistical comparison between observed and calculated intensities ($MMI \geq 2.0$) for some years between 1984 and 1994.

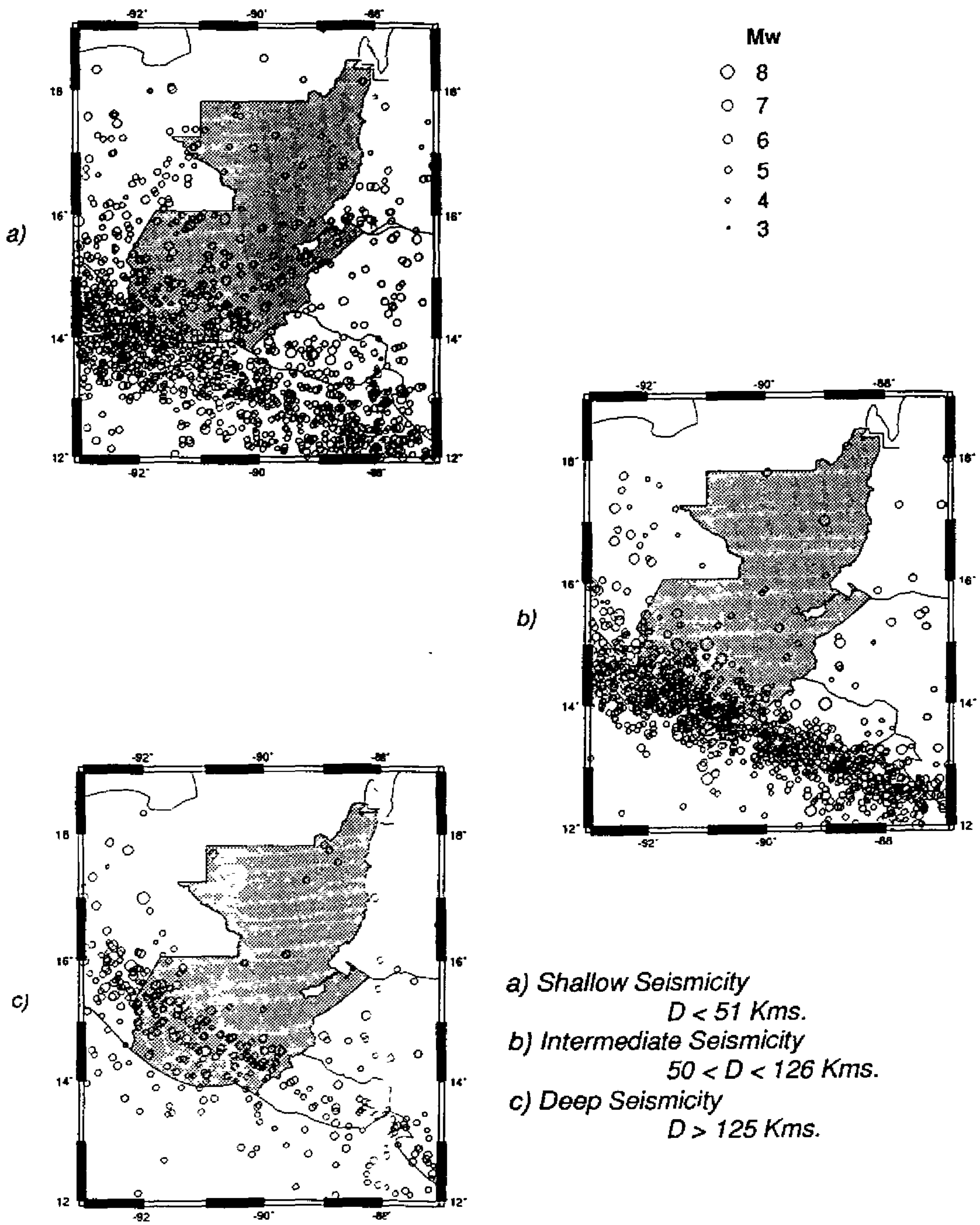


Fig. 5.1 Earthquake distribution in and around Guatemala depending on focal depth: a) shallow earthquakes (D < 50 km), b) intermediate depth earthquakes (50 < D < 125 km), and c) deep earthquakes (D > 125).

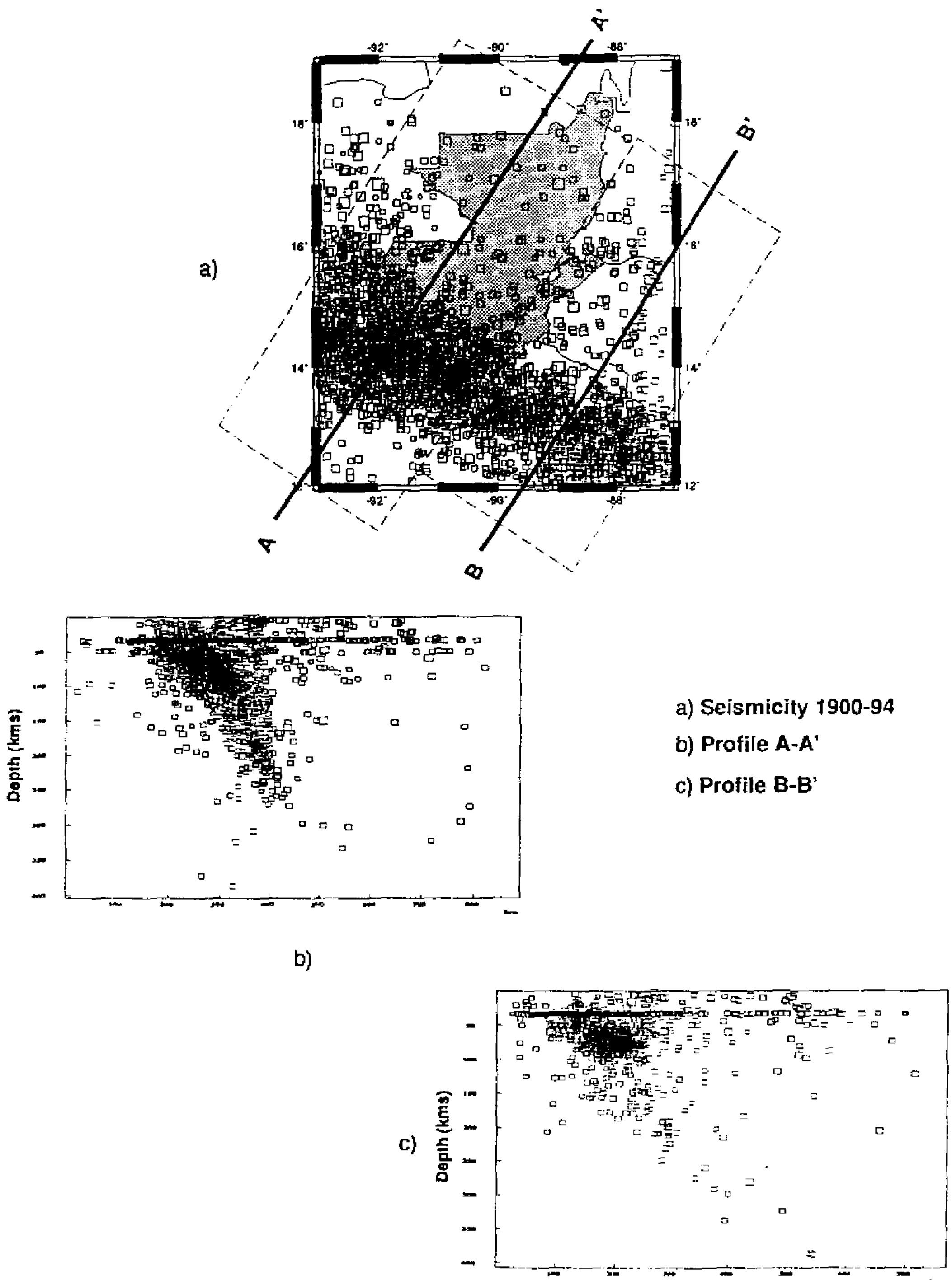


Fig. 5.2 Two seismicity profiles across Guatemala, with data from 1900-1994.

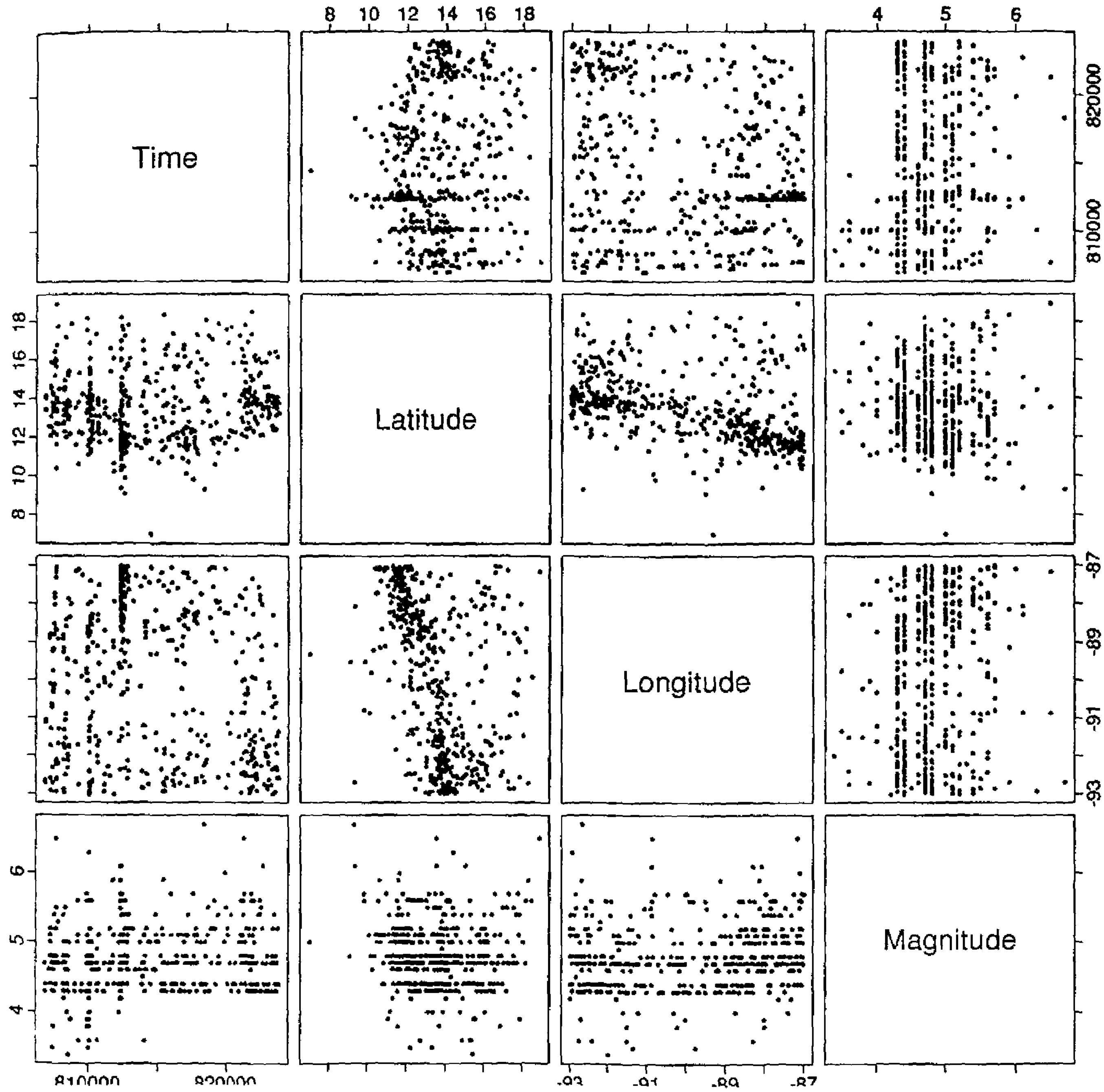
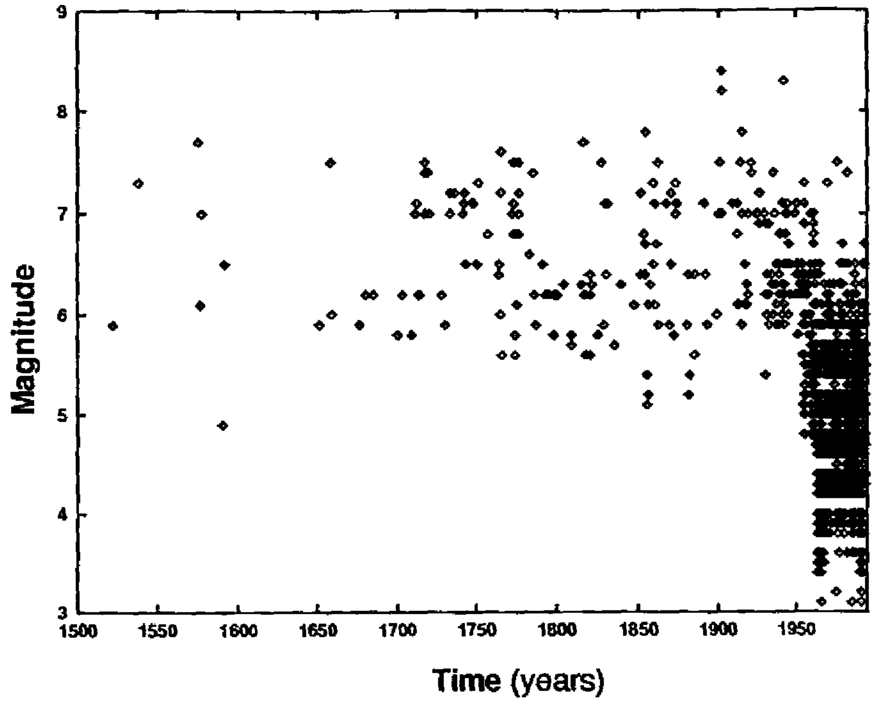
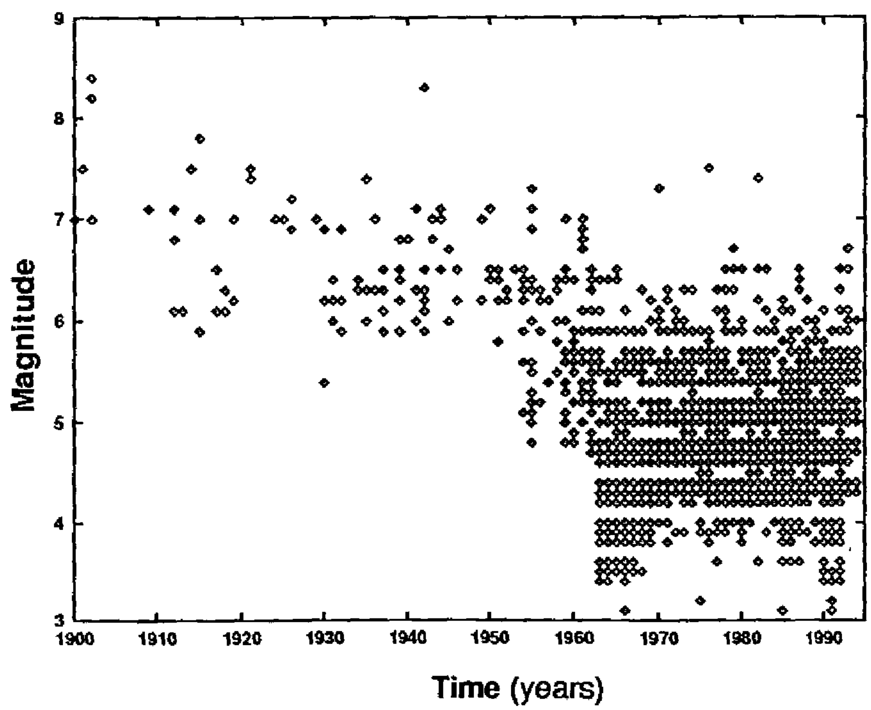
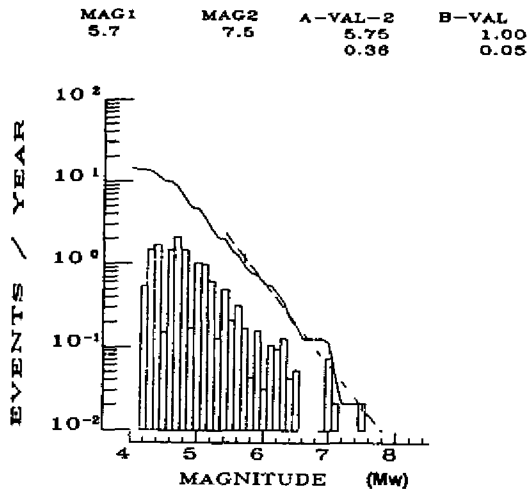


Fig. 5.3 Cluster plot used to define areas and time intervals where probable aftershocks occur. The map is symmetric and the parameters used are, from left to right and from top to bottom, time, latitude, longitude and magnitude.

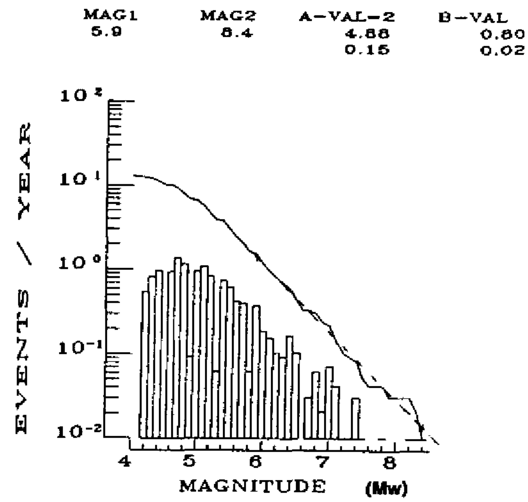




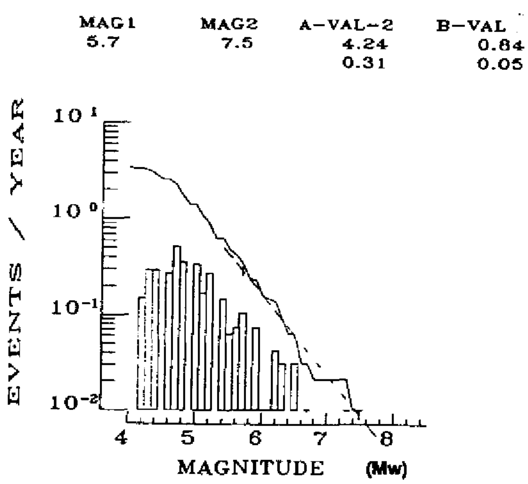
in terms of magnitude-time distributions for 1500-1994 (top), and for 1900-1994 (bottom).



a) Shallow Seismicity (D < 51 kms)

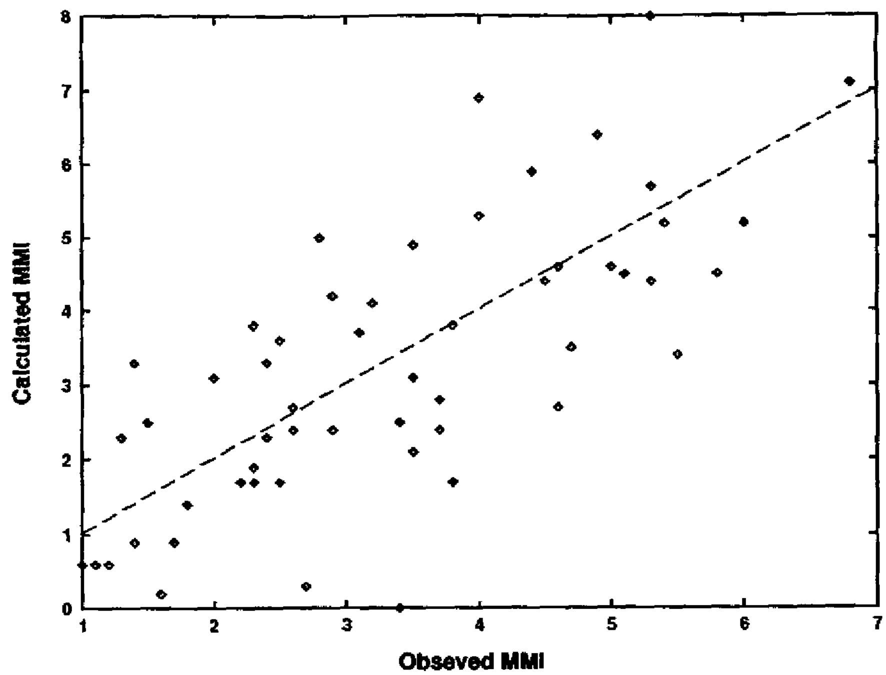


b) Intermediate Seismicity (50 < D < 126 kms)

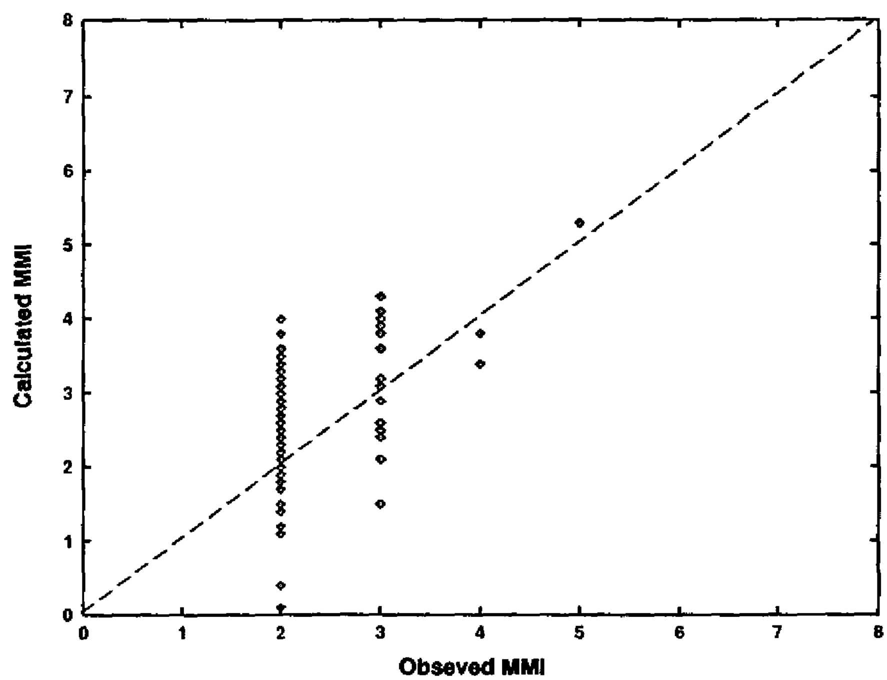


c) Deep Seismicity (D < 125 kms)

Fig. 5.5 Magnitude-frequency distributions and associated recurrence (a and b) values based on the three earthquake depth populations shown in Fig. 5.1.



a) **Comparison between observed MMI and syntethic MMI**
using the catalog prepared for this study (1900-1994)



b) **Comparison between observed MMI and syntethic MMI**
using INSIVUMEH's daily routine reports (1984-87, 1990,93, 94)

Fig. 5.6 Observed versus calculated earthquake MMI intensities in Guatemala City, for a) 1900-1994, b) 1984-1994.

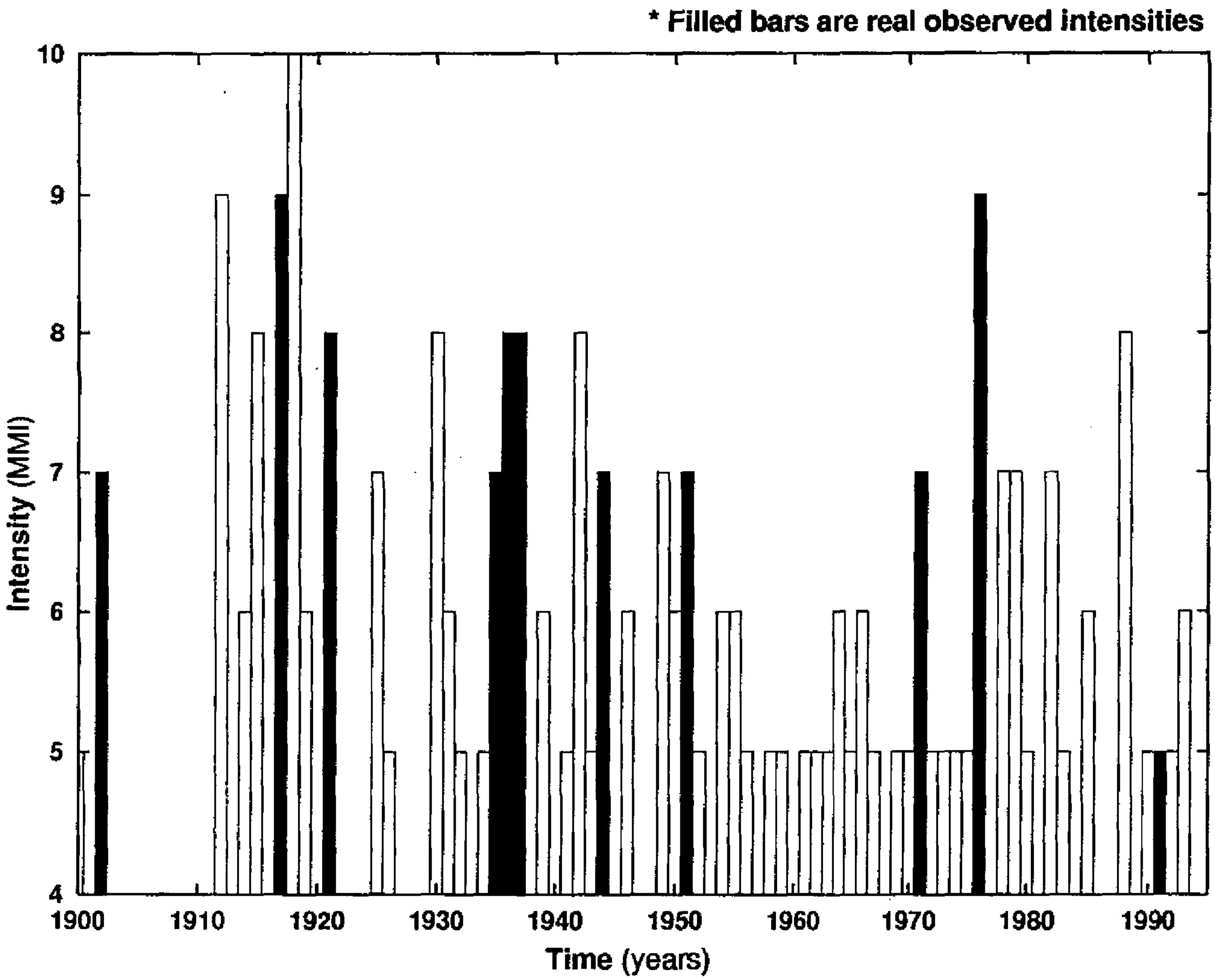


Fig. 5.7 Maximum experienced (filled bars) and expected, or calculated (open bars) MMI intensities in Guatemala City.

6 Seismic Source Definition

Site specific earthquake hazard studies have different requirements than regional ones, with a stronger focus on the local area.

In earlier sections we have provided the background for this analysis in terms of the geological, tectonic and earthquake history, regionally and locally. Two major types of seismicity sources are considered here, namely

- *seismic area zones* in cases where a considerable portion of crust and/or upper mantle is experiencing seismicity which cannot be assigned to specific structures (here taken regionally 12-19°N, 93-87°W), and
- *specific faults* in cases where there is some additional geologic evidence for the existence of active faults (here within the local area 14-15.5°N, 91.5-89.5°W).

Shallow, intermediate and deeper seismic sources were regionally defined according to the following criteria:

- The seismicity in each of the area sources must be reasonably uniformly distributed, which limits the size of a zone in areas where the seismicity varies regionally.
- Each zone should be large enough to allow for stable assessment of the recurrence parameters.
- The zones should cover all areas where the seismicity could influence the seismic hazard.
- The zonation should be consistent with regional geology and tectonic boundaries.
- Faults are included only if enough seismic and geological evidence is available and if their seismicity could influence the seismic hazard.
- Where not all of the requirements can be met, a balance between the different principles has been sought

6.1 Area Zonation

The subduction zone shows different patterns of seismicity, related to depth, concentration and magnitude generation capability (see also Redondo et al., 1993), and are the basis for defining 5 different zones.

The shallow continental crustal seismicity behaviour is even more complex than in the subduction, even though a history of destructive events and recent detailed seismicity information helps clarifying this situation.

The zones defined are:

- *Zone 1*. Subduction Zone 1. Comes from Mexico to approximately 90.5° W in Guatemala and contain shallow seismicity.
- *Zone 2*. Subduction Zone 2. A continuation of Zone 1, also with shallow seismicity and continue to El Salvador.

- *Zone 3*. Western Volcanic Chain. Shallow volcanic (specially from Tacaná and Santiaguito Volcanoes area) and tectonic seismicity, a possible continuation of The Jalpatagua Fault System (Dengo, 1992).
- *Zone 4*. Atitlán Caldera. Shallow tectonic seismicity, also part of the volcanic chain.
- *Zone 5*. Guatemala City. Shallow volcanic (specially from Fuego-Acatenango and Pacaya complexes) and tectonic seismicity.
- *Zone 6*. Jalpatagua System. Shallow seismicity along the Jalpatagua fault in a 60 km band approximately, extending from the Eastern edge of the Guatemala City graben to El Salvador.
- *Zone 7*. El Salvador-Honduras. Shallow seismicity from many undefined sources, this zone does not represent high hazard for Guatemala City
- *Zone 8*. Motagua System. Having shallow seismicity, this zone nearly divide the country in two. Its extension goes from the North-West upper limit of the Guatemala City graben to the Caribbean Sea, occupies an approximate surface width band of 50 km.
- *Zone 9*. Jocotan-Chamelecón System. Represents the shallow seismicity in the surroundings of the fault system of the same name. It is located in the triple country boundaries junction conformed by Guatemala, El Salvador and Honduras.
- *Zone 10*. Chixoy-Polochic System. Shallow seismicity along the fault system of the same name. Comes from Mexico to Guatemala.
- *Zone 11*. Mexico-Guatemala. Shallow seismicity mostly in Huehuetenango-Quiché area.
- *Zone 12*. North Mexico-Guatemala Border. Shallow seismicity in a large area mostly in Mexican territory.
- *Zone 13*. North Background. Includes all shallow seismicity lying at far North Mexico-Guatemala border and Belize. This maybe is the less seismic affected part of the region.
- *Zone 14*. Subduction Zone 3. Intermediate seismicity zone covering approximately the same longitude than zone 1 is part of the coarse zone B.
- *Zone 15*. Subduction Zone 4. Intermediate seismicity zone covering approximately the same longitude than zone 2 is parte of the coarse zone B.
- *Zone 16*. Subduction Zone 5. Deep seismicity zone, is exactly the same as coarse zone C.

See Fig. 6.1.

6.2 Specific Faults

Guatemala City is surrounded by many fault systems that are clearly seismically active (cf. Section 3).

- Fault 1. Chixoy-Polochic.
- Fault 2. Motagua.
- Fault 3. Jalpatagua.
- Fault 4. Mixco.
- Fault 5. Santa Catarina.

See Fig. 4.2

6.3 Maximum Magnitude

It has been noted earlier that the Gutenberg-Richter magnitude relation is followed for assessing the recurrence rate of seismic events. The cyclicity of earthquakes is known often to be very complicated, where we for Central America could expect some deviations from the memory free Poisson distribution, some seismic gap effects and some occurrence of the so-called 'characteristic earthquakes'. The later covers cases where the recurrence of the very largest earthquakes is not consistent with the recurrence of intermediate and small events. In practice this means that there are at times some rare large events which could not possibly be expected from previous seismicity, and one find also some times that the seismicity in decades (even centuries) following large earthquakes is difficult to describe with any known recurrence model.

In Guatemala we find two major fault zones which seems to belong to the type of seismicity described above. The North Mexico-Guatemala region and Chixoy-Polochic and Motagua-San Augustin fault systems have a very unbalanced history of earthquake occurrence, even though part of this imbalance probably can be attributed to deficiencies in the earthquake catalog. Even then the catalog serves its purpose well as a basis for assessing the seismic potentials of the different sources defined.

6.4 Recurrence values: a, b and N

A fundamental scaling relationship for earthquakes tells us that, for a given region and over a given period of time, the number of events N(M0) with seismic moment equal to or greater than M0 is given by

$$N(M_0) = AM_0^{-B} \tag{6.1}$$

where A is a variable in time and space. This is the Gutenberg-Richter (or Ishimoto-Aida) relation, which may be converted to the more common form

$$\log N = a - bM \tag{6.2}$$

This relation is essentially a power law typical for fractal sets that implies scale invariance and self-similarity, and where the coefficient b (which is related to the fractal self-similar dimension) often takes a value near or slightly less than one (e.g., Scholz, 1990).

The estimation of b-values is, as already noted, often connected with significant sources of errors and bias. We therefore calculated b-values as follows:

- Employing the depth zonation previously developed we first determined their corresponding b-value, and then this value is imposed on each of the areas developed for the respective zones to calculate their associated a-values (and thereby N-values). The different depth zone areas yielded b values between 1.00 and 0.80 for 95 years and lower bound magnitude ranging between 5.7 and 5.9, with a standard deviation of approximately 10% observed when changing time-period. The chosen values in accordance with our criteria are then 1.00 for the 13 shallow zones, 0.80 for the 2 intermediate and 0.84 for the deep zone.
- It is commonly found that b-values for specific faults are lower than regional averages (area zone values), which in fact is consistent with the concept of characteristic earthquakes. A low b-value is also called for on the basis that the cumulative moment release should decrease sufficiently fast with decreasing magnitude. Consequently we have given all of the faults a b-value of 0.60.

From the recurrence relationship it is seen that the N-values (number of events equal to or greater than magnitude M) follow directly from the a-values, which again can be determined as soon as the b-values by substituting the lower bound magnetises discussed earlier.

For each of the 16 zones and 5 faults, a-values and corresponding N-values were then calculated. The seismic source parameters used in the hazard calculations are summarized in Table 6.1 and 6.2.

Zone	a-value	b-value	M_{max}	M_{low}	N-value	Depth	Area
1	5.34	1.00	7.5	5.00	4.37	25.00	55207
2	5.03	1.00	7.5	5.00	2.14	25.00	66198
3	3.76	1.00	6.0	5.00	0.58	25.00	10766
4	4.32	1.00	6.0	5.00	0.56	25.00	5114
5	4.41	1.00	7.5	4.50	2.57	25.00	4281
6	5.07	1.00	7.5	4.50	3.72	25.00	15432
7	4.00	1.00	7.5	5.00	1.00	25.00	37382
8	4.61	1.00	7.5	5.00	0.79	25.00	32058
9	3.92	1.00	7.5	5.00	0.26	25.00	23857
10	4.10	1.00	7.5	5.00	0.13	25.00	23081
11	4.64	1.00	7.5	5.00	0.44	25.00	7264
12	4.22	1.00	7.5	5.00	0.53	25.00	51244
13	3.95	1.00	7.5	5.00	0.28	25.00	155889
14	4.73	0.80	7.5	5.00	5.37	80.00	83110
15	4.32	0.80	7.5	5.00	3.63	80.00	88200
16	4.24	0.84	7.5	5.00	1.96	150.00	219833

Table 6.1. Area zone parameterization, with a-values, b-values, maximum magnitudes, lower bound magnitudes, N values, central depth values, and sizes in km^2.

Fault	a-value	b-value	M_{max}	M_{low}	N-value	Depth	Length
1	1.20	0.60	7.0	5.00	0.016	10.00	170
2	1.56	0.60	7.67.5	5.00	0.036	15.00	101
3	1.90	0.60	7.06.8	4.50	0.158	15 00	51
4	1.50	0.60	6.5	4.50	0.063	10.00	30
5	1.50	0.60	6.5	4.50	0 063	10.00	20

Table 6.2. Fault zone parameterization, with a-values, b-values, maximum magnitudes, lower bound magnitudes, N-values, central depth values, and fault lengths.

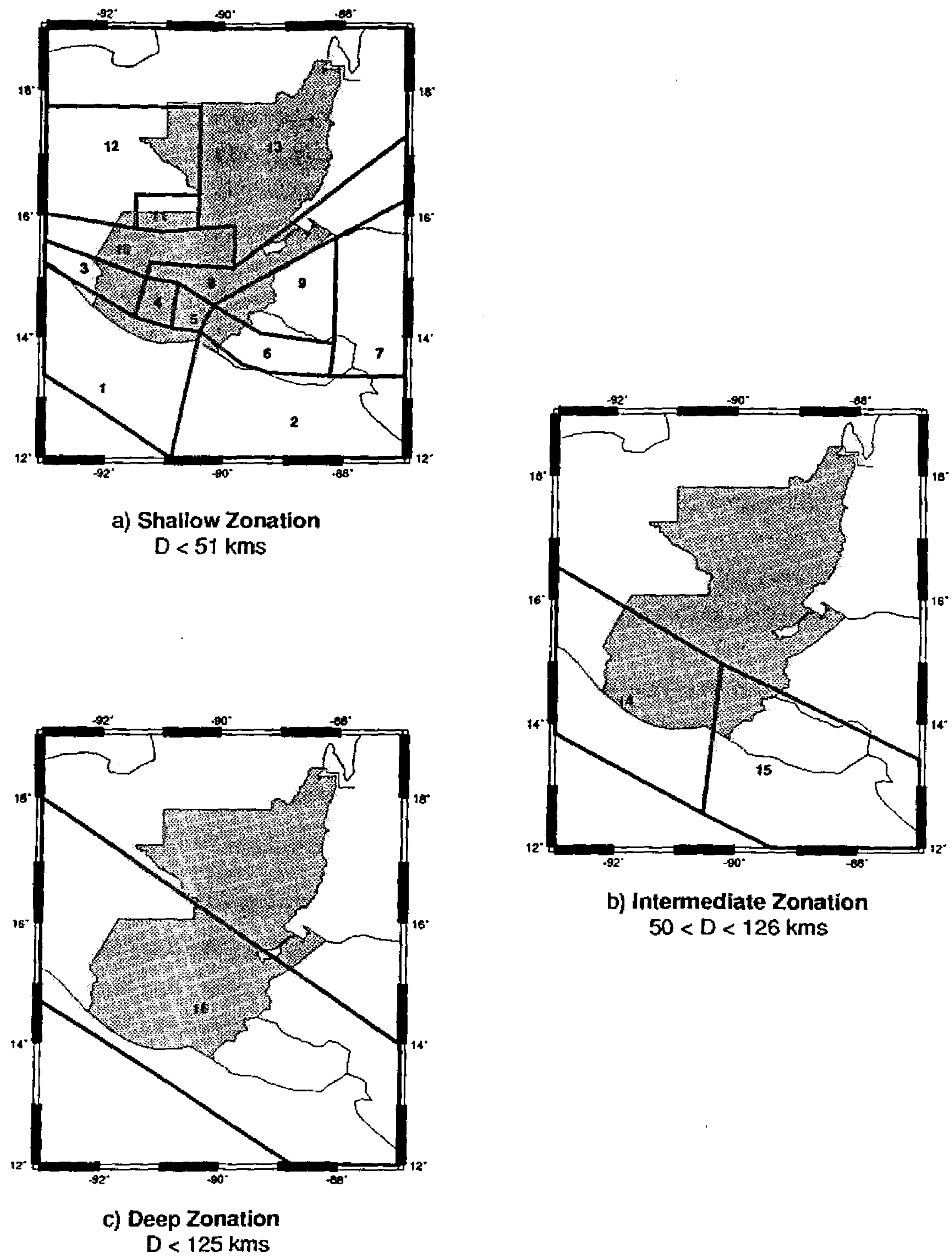


Fig. 6.1. Seismicity area zones used in this analysis, for a) shallow (D < 50 km) seismicity, b) intermediate depth (50 < D < 125 km) seismicity, and c) deep (D > 125 km) seismicity.

7 Ground Motion Attenuation Relation

7.1 Attenuation Model for Central America

A study aimed at developing a new strong motion attenuation model for Central America, based on strong motion data mostly from Costa Rica, Nicaragua and El Salvador, (Climent et al., 1994) has been performed earlier for this project. While a preliminary model from that study was used by Camacho et al. (1994 a) in their hazard modelling for Panama, another and more refined model is now available for the present study, based on a relation of the general form:

$$lnA(f) = c_1(f) + c_2(f)M + c_3(f)\,ln(R) + c_4(f)R + c_5(f)S \qquad (6.1)$$

where A is ground motion amplitude (here spectral peak ground acceleration, PGA in m/s^2) at frequency f=40 Hz, M is moment magnitude, R is hypocentral distance (in km), while S is a site factor which is 1 for soil and 0 for rock.

This latter model was also used in a hazard study for Costa Rica performed by Laporte et al. (1994) and in an updated study for Panama (Camacho et al., 1994 b).

The strong motion data used in the development of strong motion attenuation relationships by Climent et al. (1994) are shown in Fig. 7.1 in terms of their distribution in magnitude and distance. The data base has been supplemented with some large-magnitude records from Guerrero, Mexico in order to strengthen the coverage of large magnitudes and large distances.

The actual coefficients c_1 to c_5 as developed by Climent et al. (1994) are shown in Table 7.1, with the corresponding model for PGA shown in Fig. 7.2. From Equation 1.2.1 and Table 7.1, it is seen that the amplitude ratio between soil and rock is $e^{0.327}=1.39$ for PGA.

This new spectral attenuation model is developed for moment magnitudes M_W, which is the magnitude scale used also for the present assessment of the seismicity.

Freq (Hz)	c_1	c_2	c_3	c_4	c_5	Sigma
40.00	-7.214	0.553	-0.537	-0.00302	0.327	0.75

Table 7.1. Values for the coefficients c_1 to c_5 in Equation 7.1, where A is pseudo-relative velocity. Peak ground acceleration (PGA) is obtained by using the 40 Hz coefficients followed by a conversion from velocity to acceleration. From Climent et al. (1994).

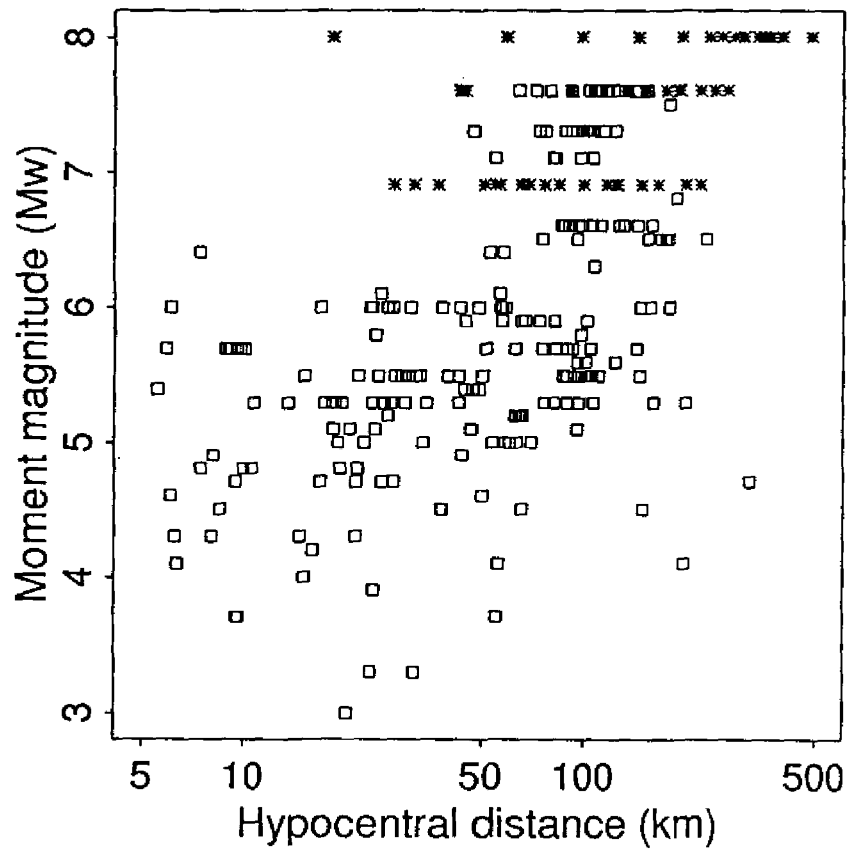


Fig. 7.1. Distribution in magnitude-distance of data used by Climent et al. (1994) in their development of the spectral strong motion attenuation model used in this study. Squares indicate Central American data and asterisks indicate data from the Guerrero strong motion network in Mexico (From Climent et al.,1994).

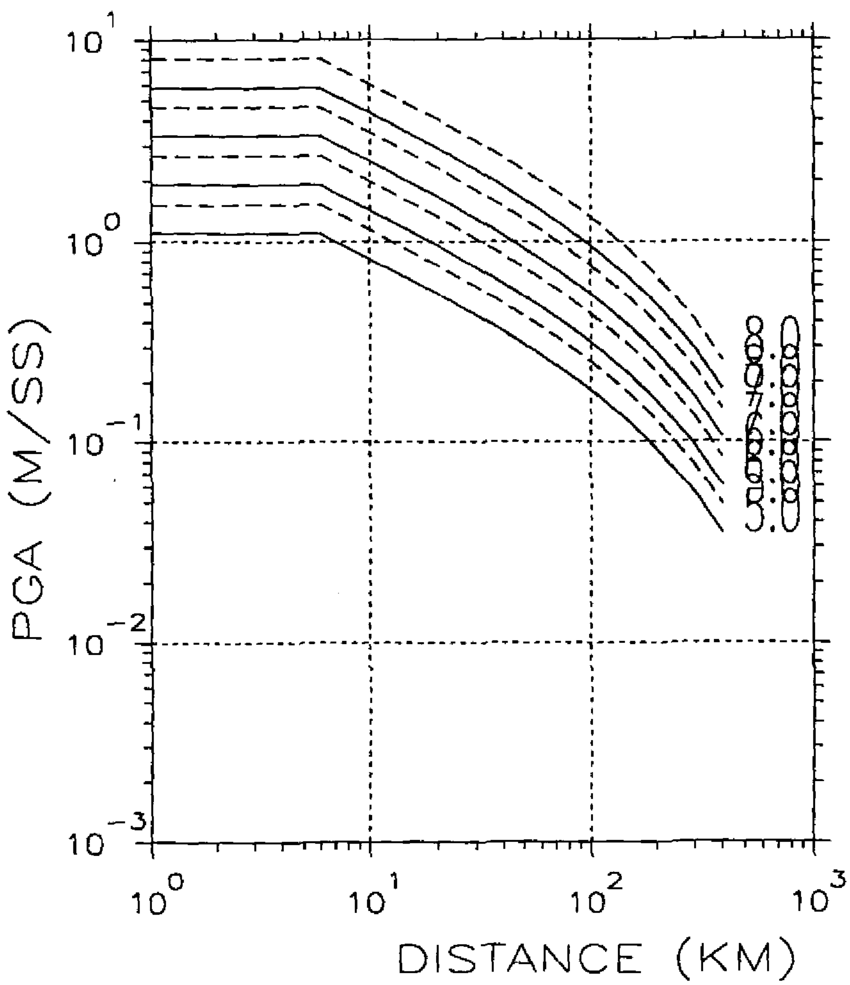


Fig. 7.2. PGA relation developed by Climent et al.(1994), shown for moment magnitudes M_W between 5 and 8. Dashed lines represent the average soil relation, while solid lines represent the rock relation.

8 Seismic Hazard Assessment

The modelling of local faults in the vicinity of Guatemala City provides the possibility to estimate site specific earthquake hazard for a point within the city, which in this study has been arbitrarily chosen as the point with geographical coordinates 90.5 W, 14.6 N.

The earthquake hazard results presented in the following have all been obtained using the logic tree probabilistic computer program NPRISK (Dahle, 1994).

All results presented below apply to the largest horizontal component of ground motion at 5% damping, and are valid for soil sites conforming to the average soil (average of soft and hard) as classified by Climent et al. (1994). Values for sites with no soil are given as soil site PGA values divided by the factor 1.39, defined in Section 7.

8.1 Computational Input Parameters

The earthquake hazard assessment is performed with the seismic area sources and fault sources as defined in Section 6. In the computations, weights different from 1.0 are given to areas containing faults, in order to compensate for the seismic activity assigned to the faults.

The actual hazard computations were performed in a logic tree formalism, where most of the parameters (models) were given a center value and two extreme values, each with assigned weight (probability).

The logic trees for the Motagua Fault (fault 2) and the area source containing the Motagua Fault (area 8) are shown in Fig. 8.1.

An overview of the input parameters for all areas sources are given in Table 8.1. and for faults in Table 8.2.

The weights for faults and for areas containing faults are summrized in Table 8.3. The reason why the sum of the weights for faults and corresponding areas sums to a number greater than 1.0 is that some of the zones are considerably larger in total area than the area actually covered by the fault.

8.2 Peak Ground Acceleration for Guatemala City

The result from the hazard computation is shown in terms of PGA versus annual exceedance probability in Fig. 8.2.

Expected values of the earthquake hazard for various annual exceedance probabilities are given both for soil and rock sites in Table 8.4. The values for a rock site are those computed for a soil site divided by the factor 1.39 defined in Section 7.

Parameter	Low	Median	High
N-values (Table 6.1)	N-value/2	N-value	2xN-value
Weights	0.2	0.6	0.2
b-values (shallow zones)	0.9	1.0	1.1
b-values (intermediate zones)	0.7	0.8	0.9
b-values (deep zone)	0.74	0.84	0.94
Weights	0.2	0.6	0.2
Max. mag. (Table 6.1)			
Weights	0.2	0.6	0.2
Focal Depth (shallow crustal zones)	10.0	25.0	40.0
Weights	0.4	0.4	0.2
Focal Depth (intermediate subduct.)	50.0	80.0	110.0
Weights	0.5	0.3	0.2
Focal Depth (deep subduction)	125.0	150.0	200.0
Weights	0.5	0.3	0.2
Attenuation scatter (sigma value)	0.5	0.6	0.7
Weights	0.3	0.4	0.3

Table 8.1. Logic tree input parameters and weights for area sources used in the earthquake hazard computations for Guatemala City.