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SEISMIC HAZARD IN GREECE. II. GROUND ACCELERATION

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ABSTRACT

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In a previous paper (Makropoulos and Burton, 1985) the seismic hazard in Greece was examined in terms of magnitude recurrence using Gumbel's third asymptotic distribution of extreme values and concepts of the physical process of strain energy release. The present study extends the seismic hazard methods beyond magnitude to the estimation of expectations of levels of peak ground acceleration exceedance thus allowing for a direct comparison between these two methodologies as well as establishing information relevant to design and planning criteria.

The limited number of strong motion records do not permit regional study of attenuation of ground vibration in Greece. An average formula is derived from eight well known formulae which resulted from worldwide studies, this is:

$$a = 2164\, e^{0.70m}(r + 20)^{-1.80} \text{ cm s}^{-2}$$

where a is peak ground acceleration, m is earthquake magnitude and r is hypocentral distance in kilometres. This formula agrees with the observed values of peak ground acceleration values recorded in Greece.

Acceleration seismic hazard is calculated at each of six chosen cities. Values of maximum acceleration with probability 70% of not been exceeded in the next 25, 50, 100, and 200 years are obtained along with corresponding values of velocity and displacement. The same detailed acceleration evaluation is then applied to the whole area of Greece by dividing it into cells of 0.5° lat.×0.5° long. and the results are illustrated through isoacceleration maps.

Differences in magnitude and acceleration hazard maps reflect the fact that in acceleration hazard assessment the focal distance from a particular place in an important factor. The cities of Heraklion and Rodhos have the lowest acceleration hazard although the expected earthquakes may have large magnitude. Intermediate depth earthquakes characterise these two cities. Acceleration estimates, unlike magnitude hazard parameters, refer to a particular place and not to an area around it. Hence, even if two places have similar earthquake depth distributions, the hazards may differ significantly because of the different spatial distribution of the foci. This is observed in the case of Athens and Corinth. These cities have almost the same magnitude hazard, but the acceleration hazard is much lower for Athens where the hazard is mainly due to more distant earthquakes.

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The isoacceleration maps for Greece as a whole also define areas of high seismic hazard. These are the areas around Cephalonia and Leukas Islands in the Ionian Sea and the eastern Sporadhes, Lesbos Islands and Chalkidiki in the Northern Aegean Sea. At the 70% probability level the maximum acceleration is expected to be around 0.2*g* within the next 50 years. The areas where the maximum acceleration at the 70% probability level is expected to reach a value of 0.3*g* in the next 200 years are around Cephalonia and Leukas Islands and near the Dardanelles.

INTRODUCTION

Seismicity and seismic hazard mapping in terms of earthquake epicentre and hypocentre distributions and average recurrence intervals of different magnitude levels are an important aspect of overall seismic hazard analyses. In Paper I (Makropoulos and Burton, 1985) we applied techniques of extreme value analysis, particularly Gumbel's third asymptotic distribution of extreme values, and concepts of the physical process of strain energy release, to the estimation of magnitude recurrence in Greece using the earthquake catalogue of Makropoulos and Burton (1981) as the data base. Other methods of analysing seismicity and seismic hazard have been applied to Greece, for example it was examined in terms of earthquake energy by Båth (1983) using a "moving block method" (Båth, 1982a,b). It is appropriate to extend these methods beyond magnitude and strain energy release to the estimation of expectations of levels of peak ground acceleration exceedance, or other parameters of ground motion. Such an extension will not only immediately make available simple physical estimates of the levels of ground vibration which are to be expected, and which may help towards design and planning criteria, but also allow comparison of seismic hazard distributions expressed both in magnitude recurrence and ground motion models. Seismic hazard patterns obtained from both models are not expected to be totally compatible and an *overall* interpretation of regional seismicity and seismic hazard is more fully approached by taking into account these *different* aspects of the same overriding seismological process.

In Paper I earthquake magnitude recurrence and strain energy release in Greece were examined in detail. This paper will extend the analysis to seismic hazard estimation principally in terms of peak ground acceleration. Some of the methods used in Paper I will be extended here to acceleration analysis. A major emphasis of this paper will be on the determination of a formula for the attenuation of peak ground acceleration with distance which is compatible with existing observations of ground acceleration in Greece. When this has been obtained extreme value analysis will be applied to computed ground acceleration values, producing commensurate seismic hazard parameters. Spatial variations in the hazard will be illustrated through isoacceleration maps, and these contrasting with the pre-existing isomagnitude maps will be seen to indicate different aspects of the seismic hazard which arise from the seismotectonic characteristics of Greece.

REPRESENTATIVE FORMULA FOR THE ATTENUATION OF GROUND ACCELERATION WITH DISTANCE

There is usually an insufficient number of earthquake strong motion records than necessary to obtain a regional study of strong motion attenuation. Esteva and Rosenblueth (1964) proposed a general formula to describe the attenuation of earthquake strong ground motion compatible with the then available data, and most of the presently available formulae modify Esteva and Rosenblueth rather than present a new model: for peak acceleration a cm s^{-2} their formula has the general form:

$$a = b_1 \, e^{b_2 m} r^{-b_3} \tag{1}$$

where a is related to the earthquake magnitude m and the focal distance r (km); b_1, b_2 and b_3 are constants to be determined. Some well known attenuation formulae are listed in Table 1 with their appropriate b_1, b_2, b_3 values. The formulae of Table 1 are plotted in Fig. 1 for a nominal magnitude $m = 7.5$ earthquake at focal depth $h = 10$ km, and these attenuation curves show considerable scatter. To estimate seismic hazard for Greece in terms of peak ground acceleration the pragmatic approach of deriving an average relation representative of the formulae in Table 1 will be adopted as a more reliable approach than adopting one individual formula in the Table. The validity of such an equation can be simply checked by its agreement with the sparse number of locally available strong motion records. The "average" equation for peak ground acceleration shown in Fig. 1 representing all the formulae

TABLE 1

Peak ground acceleration attenuation formulae from which the "average" eqn. (2) is derived

Formula	Reference	Comment
1. $a = 1080\, e^{0.5M}(r+25)^{-1.32}$	Donovan (1973)	in cm s^{-2}, more than 20 feet soil overlying the rock
2. $a = 6.6.10^{-2} 10^{0.4M} L_r^{-1.39}$	Orphal and Lahoud (1974)	in g, hard rock $\Delta b_2 = \pm 0.076$, $\Delta b_3 = \pm 0.063$
3. $a = 5600\, e^{0.8M}(r+40)^{-2}$	Esteva (1974)	in cm s^{-2}, hard rock
4. $a = 5000\, e^{0.8M}(r+40)^{-2}$	Shah and Movassate (1975)	in cm s^{-2}, hard rock
5. $a = 1230\, e^{0.8M}(r+13)^{-2}$	Ahorner and and Rosenhauer (1975)	in cm s^{-2}, hard rock
6. $a = 1.03 h^{0.6} 10^{0.54M} r^{-1.5}$	Båth (1975)	in cm s^{-2}
7. $\log a = 2.308 - 1.637 \log(r+30) + 0.411 M$	Katayama (1974)	in cm s^{-2}
8. $\log a_p = M + \log a(r) - \log A_0(M, s, p, v)$	Trifunac (1976)	in cm s^{-2} p: conf. level, s: type of soil, v: component

of Table 1 was found by trial and error to be:

$$a = 2164\, e^{0.7m}(r + 20)^{-1.80} \text{ cm s}^{-2} \qquad (2)$$

with uncertainties $\delta b_2 = \pm 0.03$ and $\delta b_3 = \pm 0.02$.

The upper, lower and average values computed for a for the whole range of the eight attenuation curves (excluding remote outliers at epicentral distances less than 50 km) at epicentral distances ranging from 10 km to 120 km and assuming $m = 7.5$ and $h = 10$ km are listed in Table 2 along with corresponding a values from (2). There are a few strong motion accelerograph records recorded in Greece which may now be used to demonstrate observational compatibility with values derived from (2). Eight accelerograph records have become readily available since the first strong motion accelerometer was deployed in Greece during 1972. Table 3 contains the maximum recorded accelerations for these shocks taken from Drakopoulos (1976), whereas the other parameters are from the MB catalogue (Makropoulos and Burton,

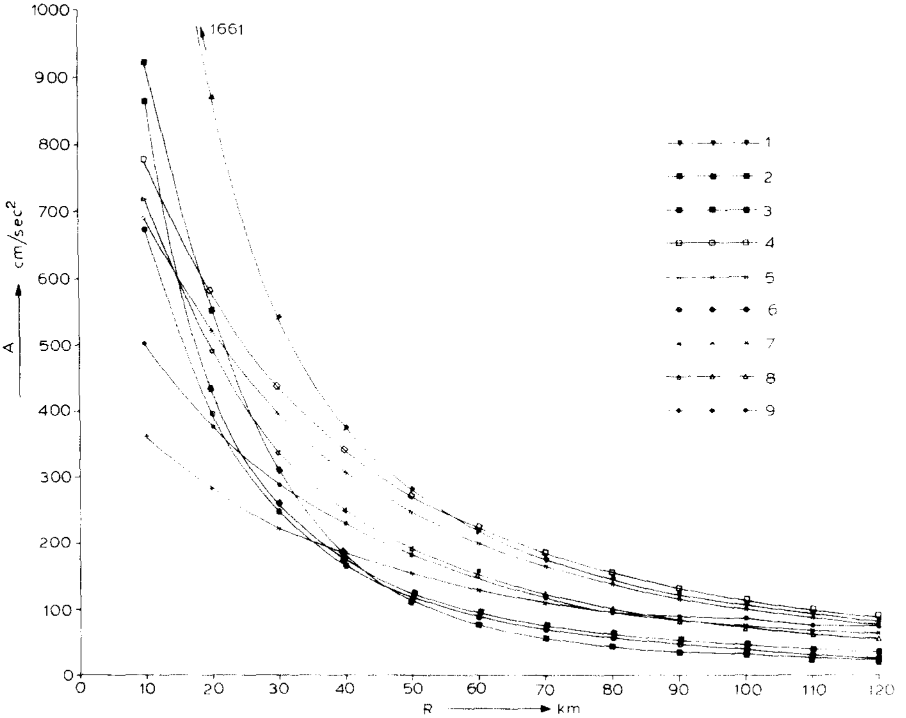


Fig. 1. Peak ground acceleration as a function of epicentral distance for a nominal earthquake of magnitude $m = 7.5$ at focal depth $h = 10$ km. The nine peak ground acceleration attenuation curves plotted include the eight formulae of Table 1 and the derived "average" formula which is eqn. (2) in the text. The curves numbered *1* to *9* are after: 1—Katayama (1974); 2—Orphal and Lahoud (1974); *3*—Trifunac (1976); *4*—Båth (1975); *5*—Esteva (1974); *6*—Shah and Movassate (1975); *7*—Ahorner and Rosenhaur (1975); 8—Donovan (1973); *9*—eqn. (2) (this paper).

TABLE 2

(a) Values of peak ground acceleration (a cm s^{-2}) for epicentral distance r km derived from the formulae of Table 1 using $m = 7.5$ and $h = 10$ km

Formula	Values for peak ground acceleration (a cm s^{-2})											
r(km):	10	20	30	40	50	60	70	80	90	100	110	120
Esteva (1974)	771	581	440	342	273	222	184	155	132	114	100	88
Båth (1975)	865	435	259	174	126	97	77	64	53	45	40	35
Donavan (1973)	–	–	253	181	151	128	111	98	87	78	70	64
Orphal and Lahoud (1974)	1661	878	542	375	280	218	177	148	125	108	95	84
Shah and Movassate (1975)	688	519	393	305	244	198	164	138	118	102	89	78
Ahorner and Rosenhaur (1975)	673	397	249	168	121	91	71	57	46	39	33	28
Trifunac (1976) ($p = 0.5$, $s = 2$, $h \leq 15$)	922	546	310	180	112	78	58	45	38	34	30	27
Katayama (1974)	501	380	288	229	186	151	128	109	95	85	74	68

(b) Range and averages of peak ground acceleration values (a cm s^{-2}) for epicentral distance r km bracketed by the eight formulae of Table 2a (excluding outlying values at epicentral distances less than 50 km) and comparable values derived from the proposed eqn. (2) in the text

	Acceleration (a cm s^{-2})											
Upper–lower value	922–673	581–397	440–249	342–168	280–112	222–78	184–58	155–45	132–38	115–34	98–30	88–27
Average value	798 ± 125	490 ± 92	345 ± 100	255 ± 87	196 ± 84	150 ± 72	121 ± 63	100 ± 55	85 ± 47	75 ± 40	64 ± 34	58 ± 30
Proposed eqn. (2)	716 ± 215	486 ± 148	340 ± 105	250 ± 79	191 ± 61	151 ± 48	123 ± 40	102 ± 33	86 ± 28	74 ± 24	64 ± 21	56 ± 19

1981). The last column gives the value of the peak acceleration calculated from (2). It can be seen that values from the "average" eqn. (2) agree with most of the observed values of peak ground acceleration, and (2) will be used throughout the ensuing hazard analysis for recurrence of peak acceleration values in Greece.

PEAK GROUND ACCELERATION SEISMIC HAZARD

General methodology: fitting to annual maximum accelerations

Equation (2) is applied to compute peak ground accelerations at a point of interest associated with each earthquake in the MB catalogue. The extreme value distributions of Gumbel (1966) are then invoked. Ranked annual maximum peak ground accelerations then form the data sample for the extreme value method, similarly to that used for annual maximum magnitudes in Paper I. An attempt to apply the three parameter (ω, u, λ) third type asymptotic distribution to the annual maximum accelerations results in poor convergence with values of the upper bounding acceleration ω as high as $10g$ and values of curvature λ close to zero. When the curvature parameter λ tends to zero the third type asymptotic curve approximates the two parameter (α, u) first type asymptotic distribution: Gumbel I.

An explanation for this may be that the value of peak acceleration computed from (2) depends not only on the magnitude, but also on the focal distance from the point of interest. Because of the nature of attenuation illustrated in Fig. 1, which is rapid for focal distances less than 40 km, and slow towards the longest distances for which the earthquake strong motion is highly attenuated, the data points are concentrated at low values of acceleration with occasional high values for rare near field earthquakes. In this situation the straight line Gumbel I seems to fit the data better than the three parameter curve of the third asymptote. The Gumbel I

TABLE 3

Observed peak ground accelerations from strong motion records of Greek earthquakes (Drakopoulos, 1976) compared with the values predicted by eqn. (2)

Date	Origin time (h:m:s)	Station	M_s	R (km)	a observed (cm s^{-2})	a from (2) (cm s^{-2})
1972 Sep. 17	14:07:15.3	Argostolion	5.9	29	170	122
1972 Oct. 30	14:32:10.7	Argostolion	5.4	28	110	90
1973 Nov. 4	15:52:12.6	Leukas	5.9	20	180	175
1973 Nov. 4	16:11:38.7	Leukas	4.9	20	80	87
1974 Jan. 29	15:12:44.8	Patras	4.3	30	40	38
1975 Apr. 4	05:16:16.5	Patras	5.7	56	58	48
1975 May 13	00:22:53.0	Xylokastron	4.6	46	74	30
1975 Oct. 12	08:23:12.6	Corinth	5.0	35	33	47

asymptotic distribution is of the form:

$$G^{1}(a)=\exp\{-\exp[-\alpha(a-u)]\} \quad (3)$$

where G is the probability that a is an annual extreme of peak ground acceleration at a point and there are two parameters: α and the characteristic modal extreme u. Equation (3) is fitted to the data which consists of annual maximum peak ground accelerations at each point of interest using linear least squares regression. In the first instance the points of interest are chosen to be the six major cities of: Athens, Thessaloniki, Patras, Corinth, Heraklion and Rodhos.

Seismic hazard in T years

From (3) it follows that:

$$a_P=u-\frac{\ln(-\ln P)}{\alpha} \quad (4)$$

where symbol P has replaced G^{l}(a) and a_P is the peak ground acceleration expected to be the annual maximum with probability P (or $1-P$ is the probability that a_P is exceeded). It follows that the peak ground acceleration a_{PT} which has probability P of not being exceeded in a T year period is given by:

$$a_{PT}=u-\frac{\ln(-\ln P)}{\alpha}+\frac{\ln T}{\alpha}$$

$$=a_P+\frac{\ln T}{\alpha} \quad (5)$$

The acceleration seismic hazard is calculated at each of the six chosen cities using (5). Table 4 lists a_{PT} for 25, 50, 100 and 200 year periods with $P=0.7$, that is 70% probability of non-exceedance of a_{PT} in the T year period.

The same procedure may be used to derive the maximum expected velocity and displacement. Values of velocity v cm s^{-1} and displacement d cm are derived using the equations of Orphal and Lahoud (1974):

$$v=0.726\ r^{-1.39}\ 10^{0.52m} \quad (6)$$

$$d=0.0471\ r^{-1.18}\ 10^{0.57m} \quad (7)$$

Results for the same probability and periods as used for acceleration are also given in Table 4. This table also includes m_{PT} for comparison, the earthquake magnitude with probability P of being the maximum during T years evaluated using the Gumbel III estimation of (6) in Paper I. In all cases the return period T' years for each of these events is given by:

$$T'=1/(1-P^{1/T}) \quad (8)$$

and for $T=25$, 50, 100, 200 years at probability $P=0.7$ the corresponding $T'\approx 70$, 140,280, 560 years. This means for example that any event in Table 4 which has a

TABLE 4

"Amplitudes" which have 70% probability of not being exceeded in T years

Amplitude of:	Magnitude *				Acceleration (cm s^{-2})				Velocity (cm s^{-1})				Displacement (cm)			
Period T yrs:	25	50	100	200	25	50	100	200	25	50	100	200	25	50	100	200
Athens	6.50	6.60	6.67	6.71	79.93	92.39	104.85	117.32	6.89	8.01	9.12	10.24	1.98	2.31	2.63	2.95
	0.16	0.21	0.25	0.30												
Thessaloniki	6.95	7.22	7.44	7.61	122.47	143.16	163.85	184.54	11.95	14.05	16.15	18.25	3.25	3.82	4.39	4.97
	0.25	0.32	0.35	0.43												
Patras	6.39	6.48	6.54	6.58	102.40	117.16	131.92	146.68	8.10	9.30	10.51	11.71	2.11	2.42	2.74	3.05
	0.18	0.25	0.28	0.31												
Corinth	6.57	6.64	6.68	6.70	117.87	136.27	154.67	173.07	10.21	11.88	13.54	15.20	2.62	3.04	3.46	3.89
	0.16	0.20	0.24	0.29												
Heraklion	6.66	6.88	7.06	7.21	55.93	63.73	71.52	79.32	4.94	5.69	6.44	7.19	1.46	1.69	1.92	2.15
	0.19	0.23	0.27	0.35												
Rodhos	6.65	6.94	7.19	7.42	63.88	73.15	82.41	91.68	6.38	7.42	8.46	9.50	1.90	2.22	2.54	2.86
	0.25	0.31	0.40	0.45												

* Magnitude values are those for distance within 100 km from the cities, derived from the third assymptote in Paper I.

70% probability of not being exceeded in 25 years has a return period of 70 years on average.

Contrasting characteristics of seismic hazard at specific cities

It can be seen in Table 4 that the maximum peak ground acceleration for the short term hazard (25 years) and the long term hazard expected in the cities of Thessaloniki and Corinth are $a_{0.7,25} \approx 120$ cm s^{-2} and $a_{0.7,200} \sim 180$ cm s^{-2} respectively. The same cities also have the highest values for the expected velocities and displacements, although these values are not necessarily associated with the same earthquake.

The difference between the hazard determined from the extreme magnitudes and accelerations at a particular place reflects the fact that in the attenuation models, the focal distance of each earthquake is taken into account. Thus, Athens and Corinth have almost the same seismic hazard in terms of expected magnitude, but they differ significantly in terms of expected acceleration, velocity, and displacement. Because these two places are characterised by similar earthquake depth distribution and are near each other (≈ 50 km), the difference shows that the seismic hazard in the city of Athens is due to relatively more distant earthquakes than in the city of Corinth.

On the other hand, the cities of Heraklion and Rhodhos are characterised by intermediate depth earthquakes and have the lowest seismic hazard in terms of expected maximum acceleration although the expected earthquakes may have large magnitudes.

SPATIAL DISTRIBUTION OF PEAK GROUND ACCELERATION EXPECTATIONS IN GREECE

A comprehensive evaluation of acceleration seismic hazard throughout Greece may now be carried out analogously to that for magnitude seismic hazard in Paper I.

Greece [$N_{33}^{42.5}$, E_{19}^{29}] is divided into a mesh of grid points at half degree intervals of latitude and longitude throughout the area. All earthquakes in the MB catalogue within 2° of each grid point are collected, corresponding peak ground accelerations computed at the grid point using the representative attenuation relationship (2), and the parameters of the Gumbel I distribution (3) obtained by fitting to ranked annual extreme peak ground accelerations. These grid point parameters thus correspond to computations for areas which overlap by about 7/8 when neighbouring computations are compared. Acceleration seismic hazard at each grid point is then computed using (5) in terms of the peak ground acceleration which has a 70% probability of being the maximum occurrence during the next 50, 100 and 200 years; that is $a_{0.7,50}$, $a_{0.7,100}$ and $a_{0.7,200}$ respectively.

The ensuing complete set of grid point values of $a_{0.7,50}$, $a_{0.7,100}$ and $a_{0.7,200}$ are contoured to produce Figs. 2–4 respectively, which thus represent different degrees of acceleration seismic hazard in terms of maximum peak ground acceleration spatially distributed throughout Greece.

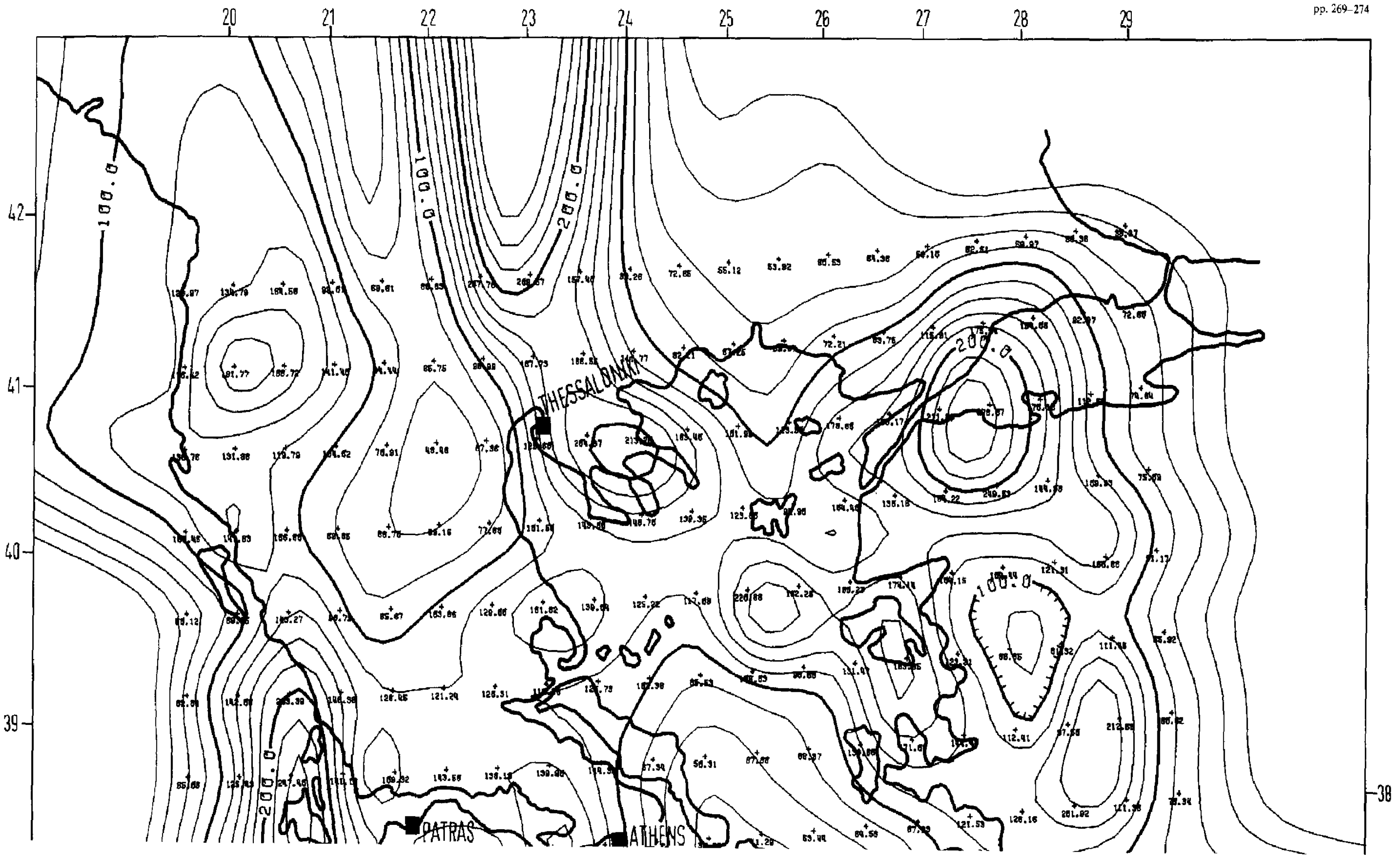
The overall picture of Figs. 2–4 shows a similar pattern. This is expected because it is apparent from (5) that the value of maximum acceleration, with a given probability of not being exceeded within a certain time, increases as a linear function of the logarithm of time. So as the time increases, the acceleration value at a particular point increases proportionally to its previous value, and therefore the shape of the isovalue contour lines do not change.

Comparing the figures which show the hazard in term of maximum magnitude (Paper I) with those of maximum acceleration shows that the pictures differ significantly mainly in the places where intermediate depth earthquakes dominate, this is the case south of 38°N. This is expected because in strong motion attenuation formulae, like (2), the focal distance from the point of interest is an important factor in calculations of the final peak ground acceleration observed at that point. Figure 2–4 also define areas of high seismic hazard, but in terms of maximum peak ground acceleration rather than magnitude occurrence. These are the areas around Cephalonia and Leukas Islands, Chalkidiki, and around Lesvos and the eastern Sporadhes Islands, with values of maximum accelerations at the 70% probability level for the next 50 years of about $a_{0.7,50} \approx 200$ cm s^{-2} (0.2g).

The areas where an acceleration of 0.3g is expected to be the maximum acceleration at the 70% probability level in the next 200 years are near the Dardanelles, and around Cephalonia and Leukas Islands.

The UNESCO Survey of the Seismicity of the Balkan region has prepared maximum acceleration hazard maps (Algermissen et al., 1976). These maps depict acceleration and velocity with 70% probability of not being exceeded in 25 and 200 year periods using data from the UNS catalogue (Shebalin et al., 1974), and attenuation formulae derived from those of Schnabel and Seed (1973). Comparing the 200 year map for acceleration with Fig. 4 shows that values from Algermissen et al.'s map are significantly higher. The main reason for the high values found in the previous work, for example $a = 0.6g$ around Cephalonia Island, seems to be the way in which the attenuation formulae were applied. Schnabel and Seed's formulae were modified so that they could be applied for two focal depths, 15 and 110 km respectively. Then all earthquakes with a depth less than 50 km were considered to have occurred at a depth of 15 km, and earthquakes with a depth of more than 50 km were considered to have occurred at 110 km. However, the vast majority of earthquakes in Greece, as the recalculated depth parameter shows (Makropoulos and Burton, 1981), have their origin at a shallow depth. 1492 out of a total of 1805 earthquakes have a depth less than 50 km, with an average depth of 28–35 km. Thus, the above considerations may lead to serious overestimation of the values computed. Drakopoulos (1976) also points out that Algermissen et al.'s values for the maximum acceleration expectations appear to be relatively high for Greece.

The computational procedure used here takes into account a full suite of individual earthquake focal parameters, and in addition there is agreement between the observed and calculated values of peak ground acceleration obtained using (2).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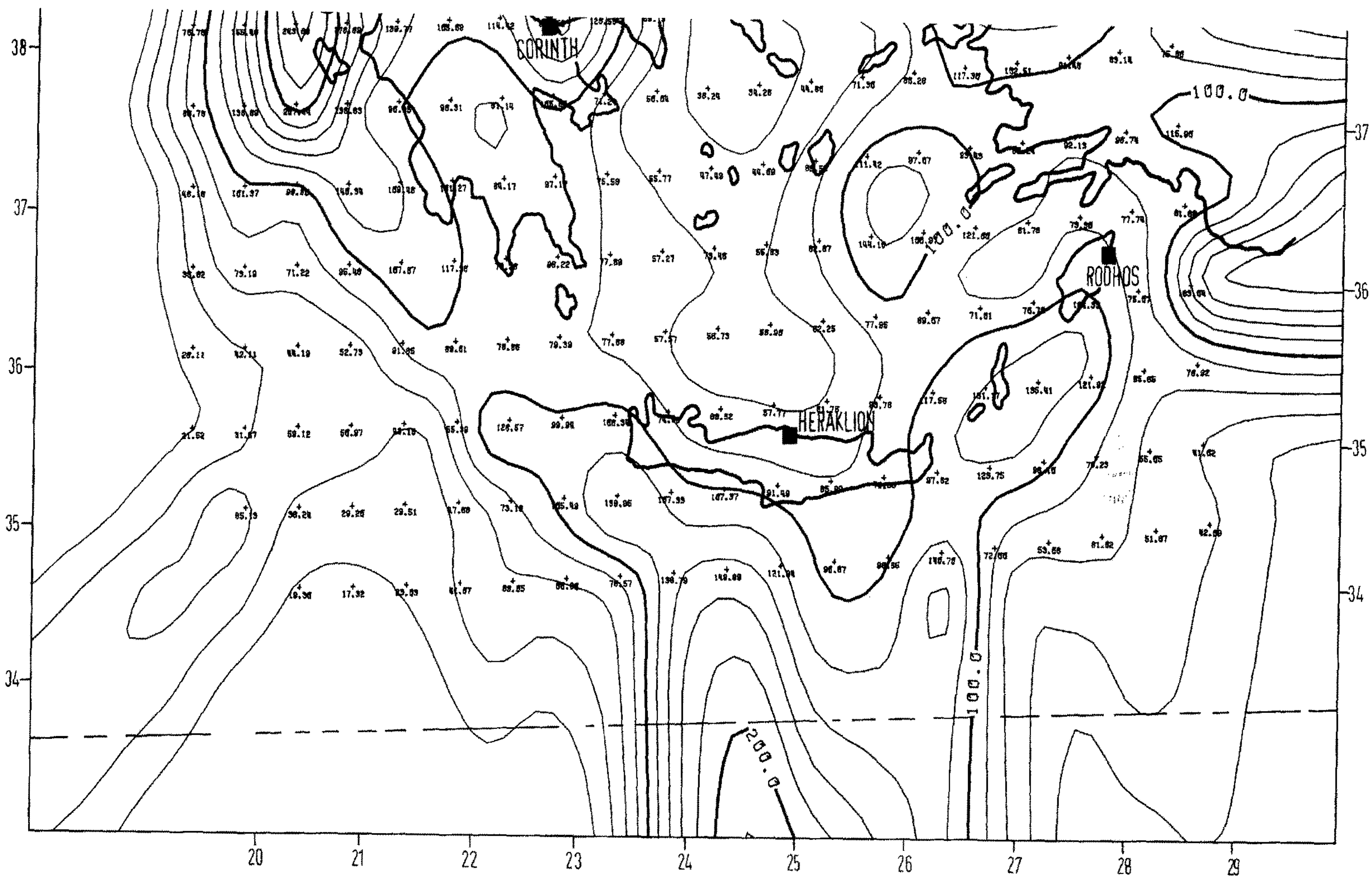
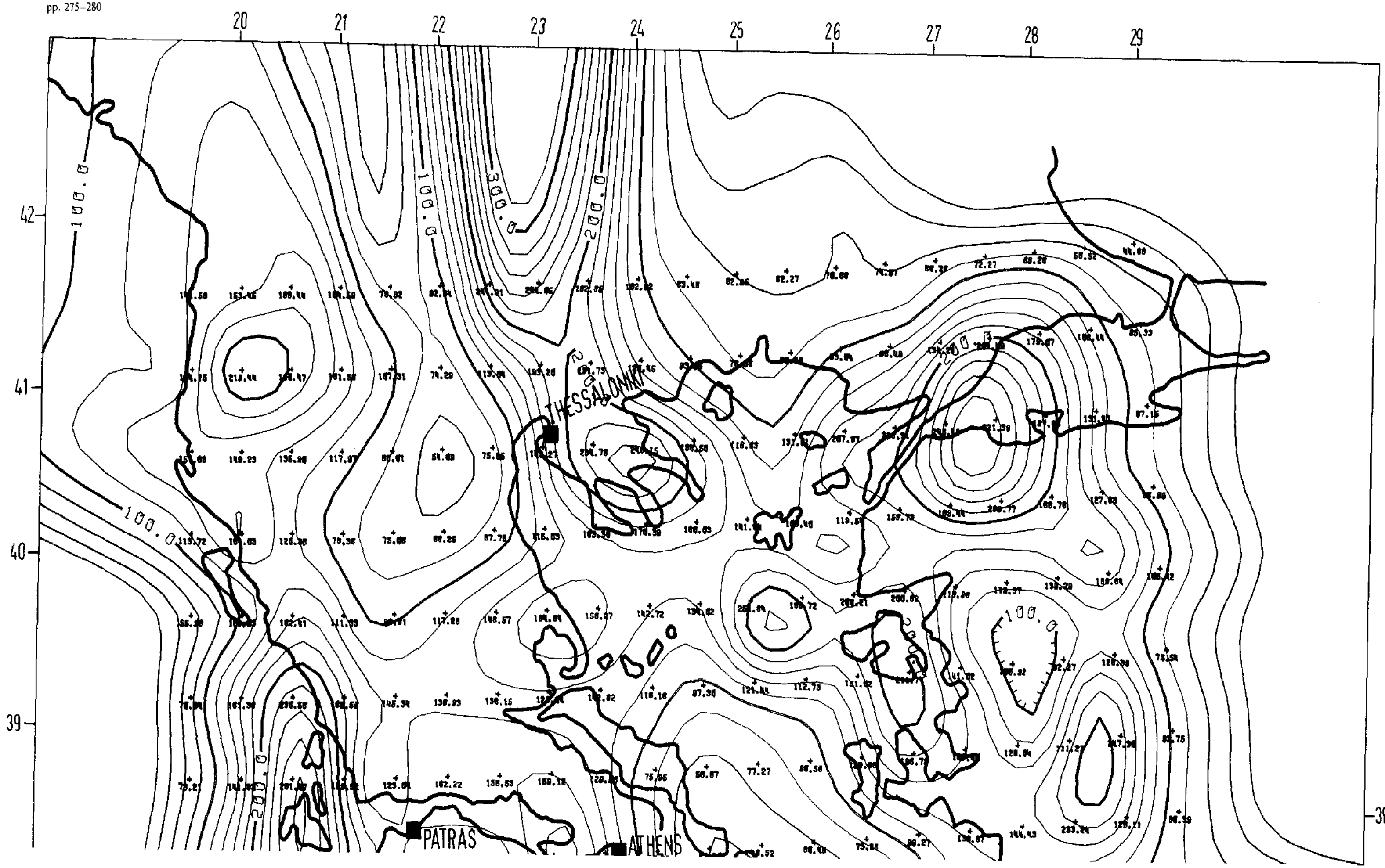


Fig. 2. $a_{0.7,50}$: maximum expected peak ground accelerations (cm s^{-2}) with 70% probability of not being exceeded in 50 years for Greece. (Contours outside the area defined by the grid of hazard data points are contouring extrapolations subject to edge effects, and are not to be considered as hazard estimates.)

pp. 275–280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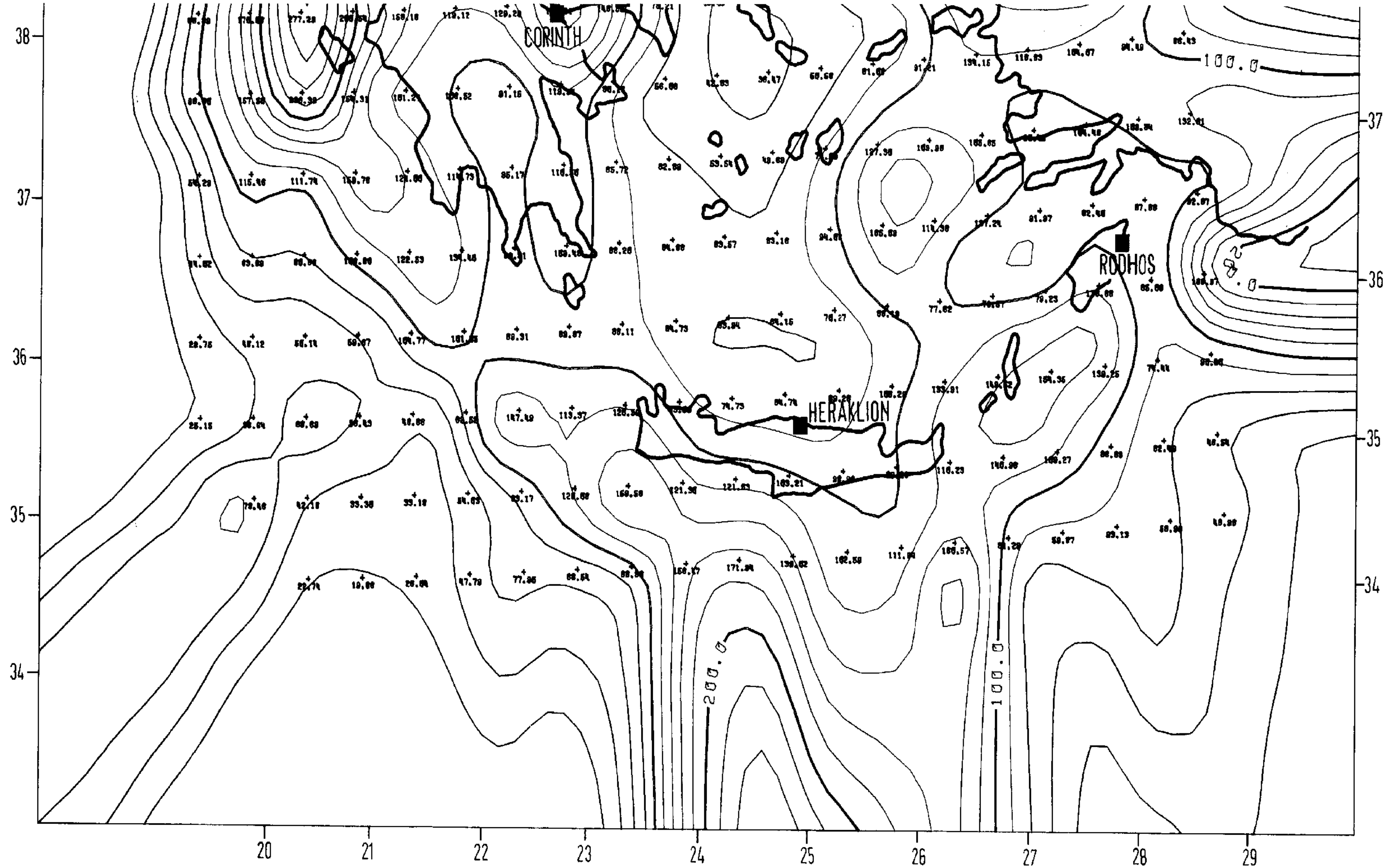

Fig. 3. $a_{0.7,100}$: maximum expected peak ground accelerations (cm s^{-2}) with 70% probability of not being exceeded in 100 years for Greece. (Contours outside the area defined by the grid of hazard data points are contouring extrapolations subject to edge effects, and are not to be considered as hazard estimates.)

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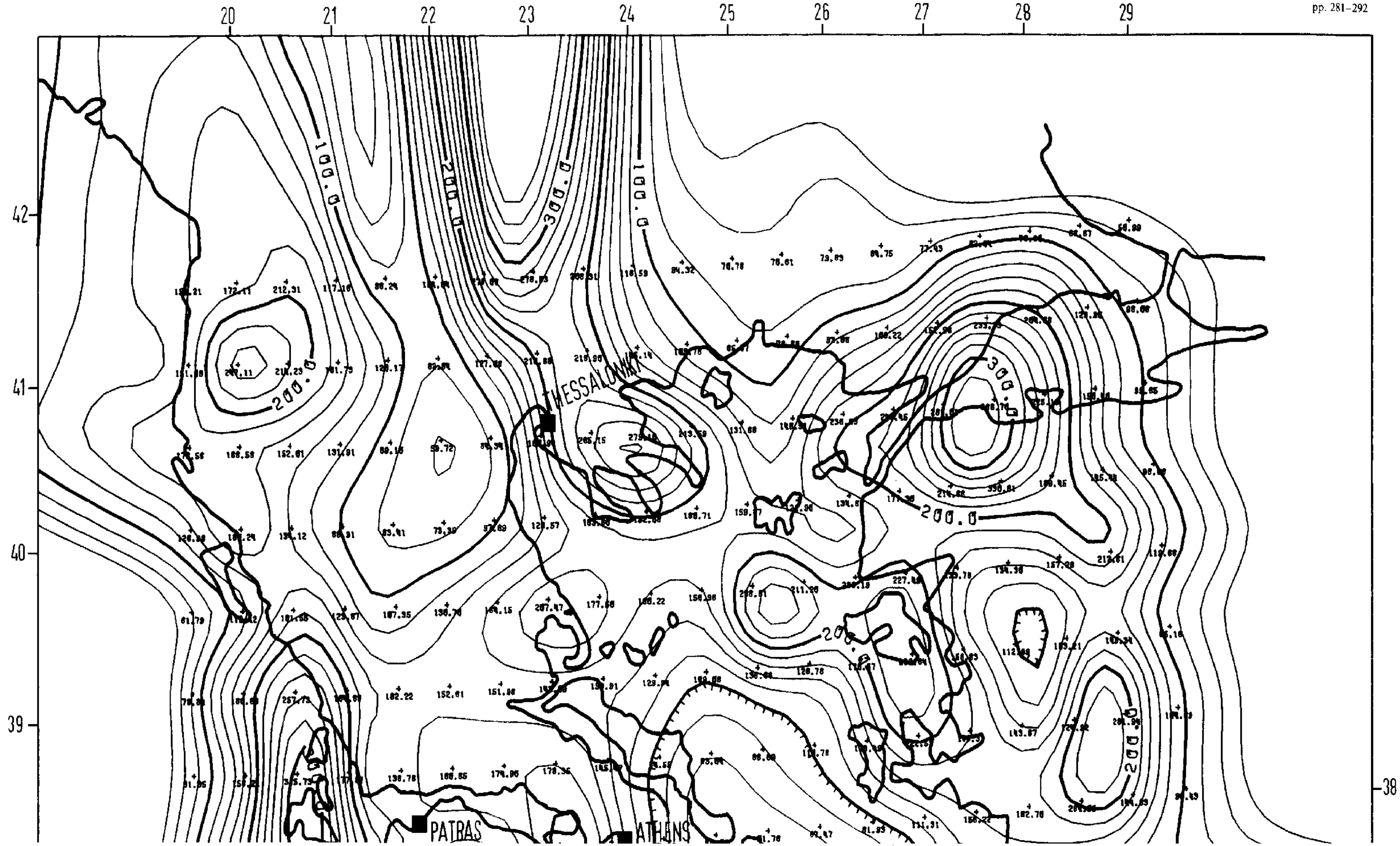
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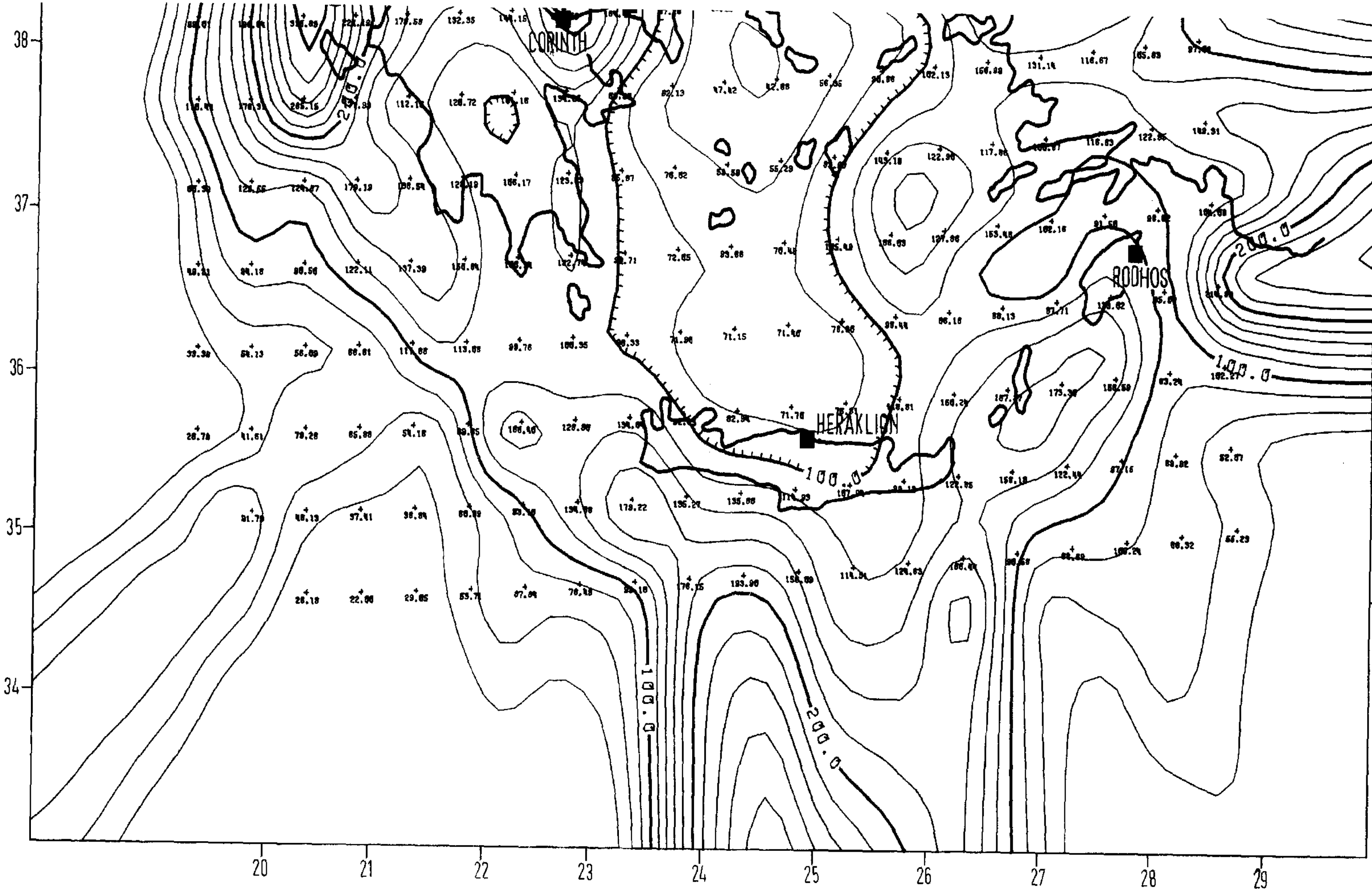

Fig. 4. $a_{0.7,200}$: maximum expected peak ground accelerations (cm s^{-2}) with 70% probability of not being exceeded in 200 years for Greece. (Contours outside the area defined by the grid of hazard data points are contouring extrapolations subject to edge effects, and are not to be considered as hazard estimates.)

thus leading to the improved seismic hazard maps of Figs. 2–4 for expectation of spatially distributed peak ground acceleration in Greece.

CONCLUSIONS

Seismic hazard methodologies and applications have been extended here for Greece beyond magnitude recurrence (Paper I) to the estimation of expectations of levels of peak ground acceleration exceedance. There is no universally applicable earthquake strong ground motion attenuation formula, nor are there sufficient readily available strong motion records from Greece to construct a regional formula. To overcome this difficulty an average attenuation law has been constructed from eight previously published and representative studies, and peak ground acceleration forecasts derived from this equation are compatible with the few observed values of peak acceleration recorded in Greece.

An attempt to use the third type asymptotic method for peak ground accelerations, however, results in poor convergence with values of $\lambda \approx 0.0$ and an unacceptable upper limit $\omega \approx 10g$. A possible explanation for this may be the tendency of the observed peak ground accelerations to cluster towards the two ends of the distribution as a result of the nature of the attenuation of the motion with focal distance. The first type asymptotic distribution appears to be a better representation of the distribution of the peak ground acceleration.

Seismic hazard estimates in terms of maximum expected peak ground acceleration values at the 70% probability level for different average return periods are entered into Table 4 for six major cities; this table also contains similar estimates for maximum ground velocities and displacements, and values of maximum expected magnitudes at the same probability level are taken from Paper I. Comparing these results for acceleration seismic hazard with those for magnitude seismic hazard in Paper I emphasizes the importance of earthquake focal distance in acceleration hazard calculations. Athens and Corinth are seen to have similar magnitude hazard but different acceleration hazard: the spatial distribution of earthquakes constructing the hazard at Athens is more distant than for Corinth. Similarly, Heraklion and Rhodes Island show lower acceleration hazard than might be expected from inspection of the magnitude hazard alone: the explanation is the predominance of intermediate depth earthquakes in this seismogenic zone.

The method of analysis which estimates acceleration hazard at specific cities can be extended to a grid of point hazard estimates, which, when contoured, produces maps of acceleration hazard throughout Greece. The isoacceleration contours show a similar pattern, despite increasing return period, resulting from linearity in the expression between peak ground acceleration and logarithmic time. The different emphasis between magnitude and acceleration hazard is regionally apparent through inspection of the isoacceleration maps, for example south of 38°N where intermediate rather than shallow depth earthquakes are dominant shows a lower acceleration hazard than might have been expected from a cursory examination of the high seismicity in the area. However, high acceleration hazard is defined around Cephalonia and Leukas Islands, and around Lesvos and eastern Sporadhes Islands. Here there is a 30% probability (1–0.7) of peak ground acceleration exceeding 0.2g within 50 years. Peak ground accelerations exceeding 0.3g at the 30% probability level in the next 200 years are expected near the Dardanelles and around Cephalonia and Leukas Islands.

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