A seismic probability map

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Summary. — The material included in former two papers (SD and EF) which summs 3307 shocks corresponding to 2360 years, up to 1960, was reduced to a 50 years period by means the weight obtained for each epoch. The weithing factor is the ratio 50 and the amount of years for every epoch.

The frequency has been referred over basis VII of the international seismic scale of intensity, for all cases in which the earthquakes are equal or greater than VI and up to IX. The sum of products: frequency and parameters previously exposed, is the probable frequency expected for the 50 years period.

On each active small square, we have made the corresponding computation and so we have drawn the Map No 1, in percentage. The epicenters with intensity since X to XI are plotted in the Map No 2, in order to present a complementary information.

A table shows the return periods obtained for all data (VII to XI), and after checking them with other computed from the first up to last shock, a list includes the probable approximate return periods estimated for the area.

The solution, we suggest, is an appropriated form to express the seismic contingent phenomenon and it improves the conventional maps showing the equal intensity curves corresponding to the maximal values of given side.

Riassunto. — Il materiale presentato nelle due ultime note (SD e EF), che comprende 3307 scosse corrispondenti a 2360 anni, fino al 1960, è stato ridotto ad un cinquantennio tenendo conto del fattore peso ottenuto per ogni epoca.

La frequenza è stata riferita al VII° di intensita della scala internazionale, per tutti i casi in cui detta intensita era compresa fra il VI° ed il IX°. La somma dei prodotti della frequenza per i parametri sucitati, è la frequenza probabile che ci si aspetta per un periodo di cinquanta anni.

Su ogni quadretto abbiamo fatto il calcolo corrispondente, disegnando così la cartina n° 1, in percentuali. Nella cartina n° 2 sono stati disposti gli epicentri dei terremoti con intensita dal X° all'XI°, allo scopo di fornire ulteriori informazioni.

Una tabella riporta i « periodi di ritorno » ottenuti per tutti i dati (dal VII° al IX°), dopo averli controllati con quelli calcolati dalla prima all'ultima scossa; la tabella V comprende i « periodi di ritorno » probabili e approssimati, valutati per la regione presa in esame.

Riteniamo questa soluzione più appropriata per esprimere gli eventuali fenomeni sismici, in modo da migliorare le carte convenzionali rappresentanti le isosiste corrispondenti ai massimi valori dell'intensità dei terremoti.

EXTRACTO. — El material presentado en dos artículos anteriores (SD y EF), que suma 3307 sacudidas correspondientes a 2360 años, hasta 1960, ha sido reducido a un periodo de 50 años mediante el peso obtenido para cada época. El factor de peso es la relación entre 50 y el numero de anos del intervalo de cada época.

La frecuencia ha sido referida a base VII de la escala internacional de grados de intensidad sísmica, para todos los casos de terremotos con intensidad igual o mayor que grado VI, y hasta el IX.

La suma de los productos de frecuencia por los parámetros anteriormente mencionados es la frecuencia probable que se espera para el periodo de 50 años.

Para cada cuadricula activa se ha hecho el cálculo correspondiente y, con esos resultatos, se ha trazado el Mapa 1, en tanto por ciento. Los epicentros de intensidad desde X a XI se han dibujado en el Mapa 2, con objeto de presentar una información complementaria.

En una tabla, se consignan los periodos de retorno para todos los datos (VII a XI) y una lista incluye los periodos de retorno, aproximados y probables, que se estiman para la región, después de haber comparado los resultados de la tabla con los calculados directamente entre el más remoto y el ultimo de los terremotos de la misma intensidad.

Se sugiere que la solución es apropiada para expresar el fenómeno aleatorio sísmico, y que mejora los mapas convencionales de isosistas trazados con los valores máximos de intensidad.

1. PURPOSE.

In former two papers (6, SD; 7, EF) we have presented several characters about the seismicity of the area 35°-44°N and 10°W-5°E, Gr. This material is applied now to draw a map which improves the conventional ones showing the equal-intensity curves (iso-lines) corresponding to the maximal values of given side, because probability is, surely, a more accurate form to express the seismic contingent phenomenon.

The map is appropriate for earthquake engineering and for comparing with tectonic or gravimetric informations.

2. Material used.

Table I resumes the data and its weight, which is as the ratio of 50 (period taken for establishing the probable frequency computation) and the number of years for each epoch. We have selected 3307 shocks, corresponding to 2360 years, and the data were reduced to a 50 years period, as it was explaines in EF.

Table I – Summary.

Epochs	Data	Interval (years)	Weight	Shocks occurred VI	VII	VIII	IX	X	XI	Sum
Historical period,										
First	–399 to 600	1000	0.05	—	—	—	3	1	—	4
Second	601 to 1300	700	0.07	—	—	4	1	1	1	7
Third	1301 to 1800	500	0.10	—	—	25	10	9	5	49
Fourth	1801 to 1900	100	0.50	34	11	18	7	2	—	72
Instrumental period, Fifth and sixth	1901 to 1960	60	0.83	138	68	35	—	4	1	246
		2360		172	79	82	21	17	7	378

Table II includes the shocks located in the area, with an intensity larger than VI° of the international seismic intensity scale.

3. Method used.

A parabola and a simplified linear expression for the whole investigated area were obtained in EF, for adjusting the regression of log N and m. The last simple expression will be used for each small square on the area, after adding log 50, because 50 is the number of years taken as the period for defining the probable frequency.

The correspondence between I_o and m, was obtained in SD from the CSE formula, assuming a normal depth. Frequency is referred to basis VII degree for shocks of intensity VI to IX; while the epicenters corresponding to X° and XI° are drawn on an independent map. The influence on the numerical values of those last shocks should increase

Table II – Shocks, vi- ix, and expectant for 50 years by 10^3 km².

Region	map	6th, 5th				4 th				3rd		2nd		1st	Sum	W.E.
		VI	VII	VIII	IX	VI	VII	VIII	IX	VIII	IX	VII	IX	IX		
1	T01	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	W04	–	1	–	–	1	–	–	–	–	–	–	–	–	2	0.4
	X05	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
		1	2	–	–	1	–	–	–	–	–	–	–	–	4	
2	W08	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	W10	–	–	–	–	–	–	–	–	–	–	–	1	–	1	0.2
	W13	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	W14	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
		2	1	–	–	–	–	–	–	–	–	–	1	–	4	
3	T16	–	1	–	–	–	–	1	–	–	–	–	–	–	2	0.9
	W17	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
		1	1	–	–	–	–	1	–	–	–	–	–	–	3	
4	T19	–	1	1	–	–	–	–	–	–	–	–	–	–	2	1.3
	T22	–	–	–	–	–	1	1	–	–	–	–	–	–	2	0.8
	U19	1	1	1	–	1	–	–	–	–	–	–	–	–	4	1.5
	U20	2	–	2	–	–	–	–	–	–	–	–	–	–	4	2.3
	U21	1	4	1	–	3	1	–	–	1	–	–	–	–	11	3.0
	U22	2	–	1	–	–	–	–	–	–	–	–	–	–	3	1.3
	W18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
	W19	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	W22	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
		7	7	6	–	4	2	1	–	1	–	–	–	–	28	
5	W26	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
6	U30	–	1	1	–	–	–	–	–	–	–	–	–	–	2	1.3
	X30	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
		–	2	1	–	–	–	–	–	–	–	–	–	–	3	
7	M01	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	N03	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	N06	–	–	–	–	–	–	1	–	–	–	–	–	–	1	0.6
	R01	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	R03	3	–	–	–	–	–	–	–	1	–	–	–	–	4	0.4
	R04	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	R06	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	S03	3	–	–	–	–	–	–	–	–	–	–	–	1	4	0.6
		9	1	–	–	1	–	1	–	1	–	–	–	1	14	
8	K17	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	N15	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	S13	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	U11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
		2	–	–	–	1	–	–	–	–	–	–	–	–	3	
9	N18	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	N21	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	P22	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	R18	1	1	–	–	–	–	–	–	–	–	–	–	–	2	0.5
	S17	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	S19	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
		3	2	–	–	2	–	–	–	–	–	–	–	–	7	

Table II: *continuation.*

Region	map	6th. VI	VII	5th VIII	IX	4th VI	VII	VIII	IX	3rd VIII	IX	2nd VIII	IX	1st IX	Sum	W.E.
10	R24	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	R25	4	–	–	–	1	–	–	–	–	–	–	–	–	5	0.6
	S23	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	S24	2	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
	S25	–	1	–	–	–	–	1	–	1	–	–	–	–	3	1.1
	S26	1	–	–	–	–	–	–	–	1	–	–	–	–	2	0.3
	T23	1	–	–	–	–	–	–	–	1	–	–	–	–	2	0.3
	T24	1	–	–	–	–	1	–	–	–	–	–	–	–	2	0.3
	T25	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	T26	–	–	–	–	–	–	–	–	–	3	–	–	–	3	0.7
	T27	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	U23	–	–	–	–	1	1	–	–	–	–	–	–	–	2	0.3
	U24	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
		10	2	1	–	4	2	1	–	3	3	–	–	–	26	
11	J02	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
	J04	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	J05	1	1	–	–	1	–	–	–	–	–	–	–	–	3	0.5
	K02	3	1	1	–	1	–	1	–	1	1	–	–	–	9	2.8
	K03	2	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
	K04	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	K05	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	L02	2	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
	L03	1	1	–	–	–	–	–	–	–	–	–	–	–	2	0.5
	L05	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
		12	4	2	–	2	–	1	–	1	1	–	–	–	23	
12	K09	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
13	D04	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	E03	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	E04	2	–	–	–	1	–	–	–	2	–	–	–	–	5	0.7
	E05	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
	H03	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—
	H04	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	H05	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
		6	–	–	–	1	–	–	–	2	–	–	–	–	9	
14	D06	–	1	–	–	–	–	–	–	2	–	–	–	–	3	0.6
	D08	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	E06	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	E09	–	–	–	–	–	–	–	–	–	–	1	–	1	1	0.1
		2	1	–	–	–	–	–	–	2	–	1	–	1	6	

Table II: *continuation.*

Region	map	6th, 5th				4th				3rd		2nd		1st	Sum	W.E.
		VI	VII	VIII	IX	VI	VII	VIII	IX	VIII	IX	VIII	IX	IX		
15	D10	1	–	–	–	1	–	–	–	–	–	–	–	–	2	0.2
	D12	3	–	–	–	1	–	–	–	1	–	–	–	–	5	0.6
	D13	1	2	–	–	–	–	–	–	–	–	–	–	–	3	0.8
	D14	3	2	1	–	1	–	1	–	–	–	–	–	–	8	2.7
	D15	1	–	–	–	1	–	–	–	1	–	–	–	–	3	0.3
	E10	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	E12	1	1	–	–	–	1	1	1	–	–	–	–	–	5	2.5
	E13	6	1	2	–	1	–	1	–	1	–	–	–	–	12	3.9
	E14	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	E15	2	–	1	–	–	–	1	–	2	–	–	–	–	6	2.1
	E16	1	–	–	–	–	–	1	–	–	–	–	–	–	2	0.7
	E17	1	–	–	–	–	–	–	–	–	1	–	–	–	2	0.4
	H11	–	1	–	–	–	–	–	–	–	–	2	–	–	3	0.5
	H12	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
	H15	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	H17	1	–	–	–	–	–	–	–	1	–	–	–	–	2	0.3
	J13	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
	J17	3	2	–	–	–	–	–	–	–	–	–	–	–	5	1.1
		26	9	6	–	6	1	5	1	6	1	2	–	–	63	
16	H18	3	3	1	–	1	1	–	–	–	–	–	–	–	9	2.7
	H19	2	1	–	–	1	1	1	–	–	–	–	–	–	6	1.5
	E21	–	–	–	–	1	–	–	–	–	–	–	–	–	1	0.1
	J18	4	3	1	–	–	–	–	–	–	–	–	–	–	8	2.5
	J19	4	2	1	–	2	–	–	1	–	–	–	–	–	10	3.5
	K18	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
	K19	1	1	–	–	–	–	–	–	2	1	–	–	–	5	0.9
	K20	1	1	–	–	–	–	–	–	1	–	–	–	–	3	0.6
	L18	–	–	–	–	–	–	–	–	1	–	–	–	–	1	0.1
	L19	–	–	–	–	–	–	1	–	–	–	–	–	–	1	0.6
	L20	–	–	–	–	–	–	–	–	1	–	–	–	–	1	0.1
	M18	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
		16	11	4	–	5	2	2	1	5	1	–	–	–	47	
17	M23	–	–	–	–	2	–	–	–	–	–	–	–	–	2	0.2
	M24	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	M26	–	–	–	–	–	–	–	–	1	–	–	–	–	1	0.1
	M29	–	–	–	–	–	–	–	–	–	–	–	–	–	—	—
		1	–	–	–	2	–	–	–	1	–	–	–	–	4	
18	A01	–	1	–	–	–	–	–	1	–	1	–	–	–	3	1.8
	A06	–	–	–	–	–	–	1	–	–	–	–	–	–	1	0.6
	B01	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	B02	–	–	–	–	–	–	–	–	–	1	–	–	1	2	0.4
		1	1	–	–	–	–	1	1	–	2	–	–	1	7	

Table II: *continuation*.

Region	map	6th, 5th VI	VII	VIII	IX	4th VI	VII	VIII	IX	3rd VIII	IX	2nd VIII	IX	1st IX	Sum	W.E.
19	A08	–	–	–	–	–	–	–	–	–	–	1	–	–	1	0.1
	A09	–	–	–	–	–	–	–	–	–	–	–	–	–	—	—
	A10	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
	B07	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	B09	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	C08	–	–	–	–	–	–	–	–	–	–	–	–	1	1	0.1
	C10	2	1	–	–	–	–	–	–	–	–	–	–	–	3	0.6
		3	2	1	–	–	–	–	–	–	–	1	–	1	8	
20	A11	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	A12	–	1	–	–	1	–	–	–	–	–	–	–	–	2	0.4
	A13	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	A14	–	1	–	–	1	–	1	–	–	–	–	–	–	3	1.0
	A15	–	2	–	–	–	–	–	–	–	–	–	–	–	2	0.7
	A16	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	B12	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	C12	–	–	–	–	–	–	–	–	–	1	–	–	–	1	0.2
	C14	2	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
		4	6	–	–	2	–	1	–	–	1	–	–	–	14	
21	A19	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	A21	1	–	–	–	–	–	–	1	–	–	–	–	–	2	1.3
	B19	2	1	–	–	1	–	–	–	–	–	–	–	–	4	0.6
	B20	2	1	–	–	–	–	–	–	–	–	–	–	–	3	0.6
	B21	1	–	–	–	1	1	–	1	–	–	–	–	–	4	2.5
		7	2	–	–	2	1	–	2	–	–	–	–	–	14	
22	A23	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	A27	2	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
	B22	1	1	1	–	–	–	–	–	–	–	–	–	–	3	1.5
	B24	1	–	1	–	–	–	–	–	–	–	–	–	–	2	1.1
	B26	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	B27	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	B29	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
	B30	–	2	–	–	–	–	–	–	–	–	–	–	–	2	0.7
	C23	5	2	3	–	–	–	–	–	–	–	–	–	–	10	4.3
	C24	3	1	–	–	–	–	–	–	–	–	–	–	–	4	0.7
	C25	–	–	1	–	–	–	–	–	–	–	–	–	–	1	1.0
	C26	2	4	2	–	–	2	2	1	–	–	–	–	–	13	6.3
	C27	–	–	1	–	1	–	–	–	–	–	–	–	–	2	1.1
	C28	3	1	1	–	–	–	–	–	–	–	–	–	–	5	1.7
	C29	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	C30	–	–	1	–	–	–	2	–	–	–	–	–	–	3	2.2
	D23	–	1	–	–	–	–	–	–	–	–	–	–	–	1	0.3
	D24	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	D25	1	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1
	D26	1	–	1	–	–	–	–	–	–	–	–	–	–	2	1.1
	D27	2	–	–	–	1	–	–	–	3	1	–	–	–	7	0.9
	D30	–	–	–	–	–	–	–	1	–	–	–	–	–	1	1.2
		25	13	13	–	2	2	4	2	3	1	–	–	–	65	

very much the frequency percentage and, on the other hand, there are few of them and therefore, we believe it is better for clearness of that map that these epicenters were symbolized by circles of different diameter, exception made of the single deep shock.

Thus, in the formula (for N in 50 years),

$$\log N = 7.551 - m$$

magnitude is substituted by intensity, and Table III shows the relative values over VII°, for each frequency.

Table III – PARAMETERS, BASIS VII°.

I_0	m	$\log N_{50}$	1.751–	C	$10^3 km^2$	5,6	4	3	2	1
VI°	5.4	2.151	$\bar{1}.6$	0.4	0.16	0.13	0.08	—	—	—
VII°	5.8	1.751	0	1.0	0.40	0.33	0.20	—	—	—
VIII°	6.3	1.251	0.5	3.0	1.20	1.00	0.60	0.12	0.08	—
IX°	6.7	0.851	0.9	6.0	2.40	1.99	1.20	0.24	0.17	0.12

It is supposed that frequency is homogeneous within every small square. The surface of a small square is 0.5×0.5 geographic degrees (2,500 km^2). For obtaining the true values, by 10^3 km^2, it will be necessary to take 2/5 of these values, after affecting them of their weight. Table III includes the weighting factors corresponding to each epoch and intensity.

The homogeneity assumption is equivalent to accept up to a half geographic degree as the accuracy for epicentral determination and, thus, we can use all the data, including those of the old epochs.

The local expectant (or mean, probable, approximate frequency to be expected for a future interval of 50 years) will be the result obtained from the sum of the products of the Table III factors multiplied by the number of shocks located for each epoch and intensity. These shocks are quoted in Table II. The last column of the Table II shows the expectants corresponding to each 1000 km^2, as we before said.

4. MAPS.

Following a topographic criterion, the equal-probability-curves have been drawn, as Figure 1 shows. For clearness, only the curves with values

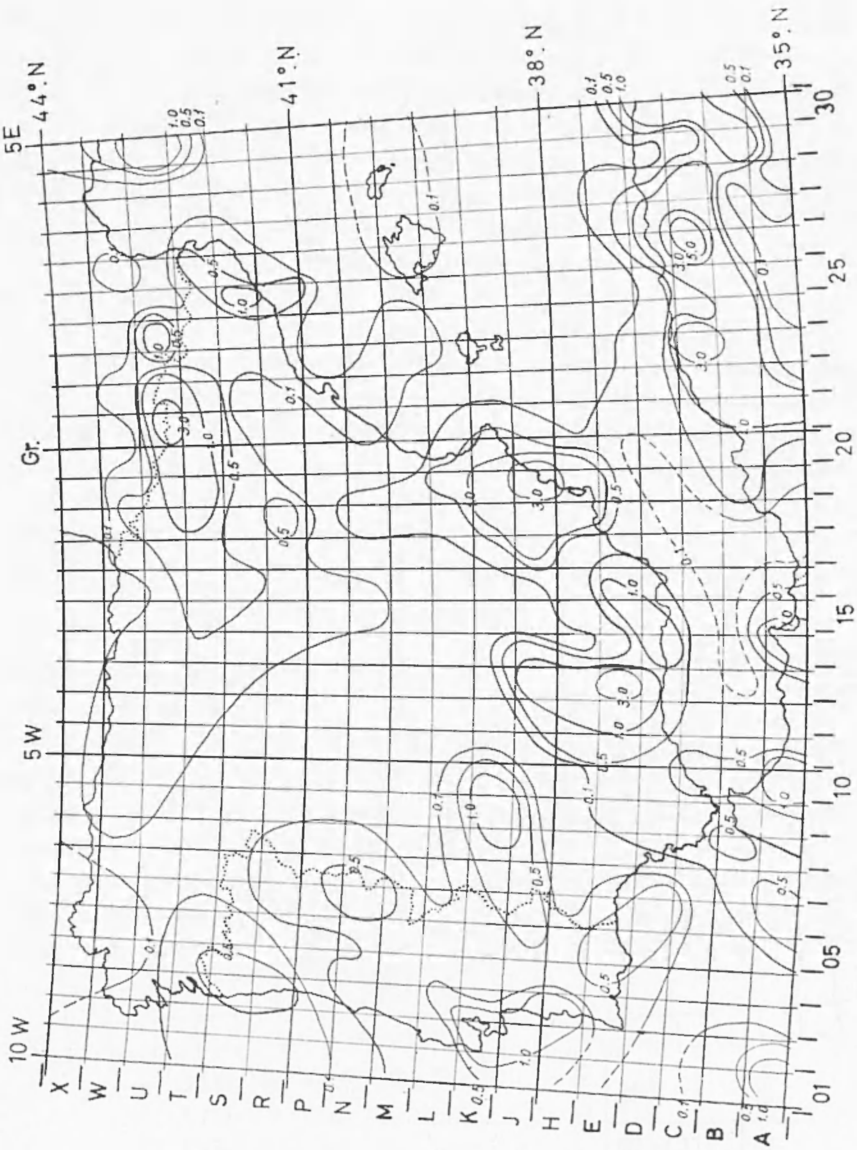

Figure 1 – Probable seismic frequency (basis VII) for 50 years on 1000 km².

0. 1, 0.5, 1.0, 3.0, have been drawn on the map. These curves surround the corresponding small squares. Looking Table III we can see the percentage over VII° referred to 1000 km² and with weight, versus a whole degree of one shock by a whole small square. In consequence, it is very easy to

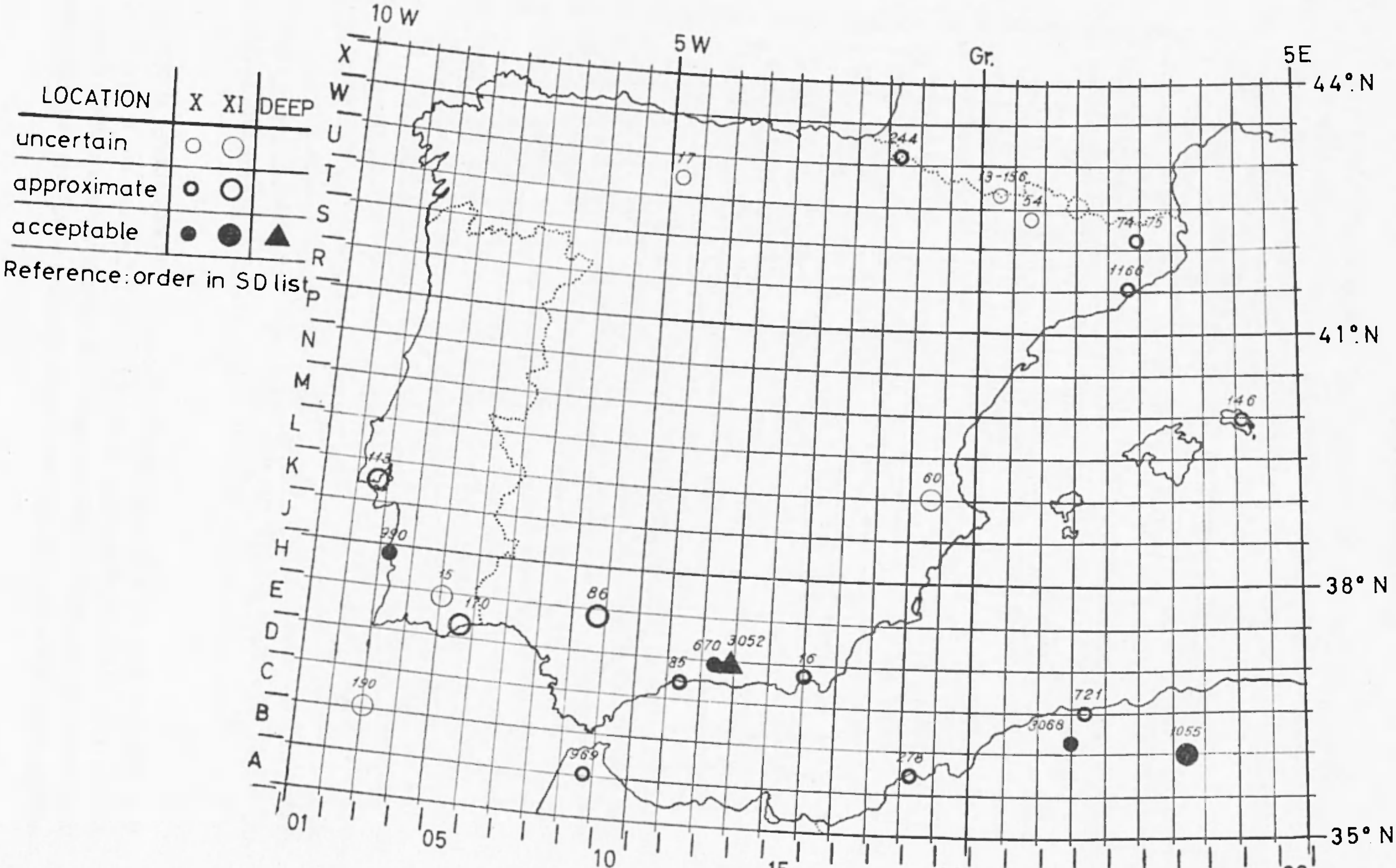

Figure 2 – Noticeable earthquakes, occurred in the area, to 1960.

draw a map for equal-probable-intensity curves (probability iso-lines). The curves could be drawn jointing the centers of each active small squares, which have the same value of intensity.

Figure 2 presents the X° and XI° epicenters and also the deep shock of Andalucia. These are the noticeable shocks occurred in the area till 1960 and they are listed in the Table IV. We use the intensity scale suggested by Richter, which takes in account four references for different kinds of masonry; other similar scale was compilated by Medvedev, Sponheuer and Karnik, in 1962, and it was proposed by European Seismological Commission, CSE.

Certainly, it is preferable to have a map of iso-probability-lines for seismic zone; Figure 1 is also useful for this purpose. When the expectant is smaller than 0.16 (intensity minor than VI° for a given small square) seismicity is of course not appreciable. For expectant from 0.16 to 2.4 (VI°-IX°), seismic activity is progressively increasing; but, if the expectant is larger than 2.4 (intensity higher than IX°, for a certain small square) it is absolutely necessary to take into account seismic activity, which may be dangerous for people and buildings.

5. Return periods.

As an additional information which could help for further studies and applications, Table V has written the return periods for the selected quakes from VII up to XI dg, occurred for every 22 regions established in the area (see EF) and also for the whole area.

The return period (inverted of the probability or interval expressed in years during which a quake of a given degree is to be expected) is deduced from the data grouped in the following form:

I_0	epoch			years
VII°	5th	and	6th	60
VIII°	4th	to	6th	160
IX°	3rd	to	6th	660
X°	2nd	to	6th	1360
XI°	1st	to	6th	2360

These intervals, of the last column, divided by the number of earthquakes corresponding to each active small square (Table II) give the values

Table IV – Noticeable earthquakes in the area (X°, XI° and deep one).

Region	map	Epoch	Data	I_o	Coordinates		Location	Order SD	Remarks
8	U11	2	949	X	42.7	—4.8	uncertain	17	
4	W18	3	Oct 1772	X	43.2	—1.3	approximate	244	
4	U21	1	585	X	42.7	+0.3	uncertain	13	
4	U21	3	Jul 1678	X	42.7	+0.3	uncertain	156	
4	T22	3	2 Feb 1374	X	42.4	+0.8	uncertain	54	
10	T25	3	15 May 1427	X	42.2	+2.5	approximate	74	
10	T25	3	2 Feb 1428	X	42.2	+2.5	approximate	75	
10	R25	5	22 Oct 1912	X	41.5	+2.3	approximate	1166	
11	K02	3	26 Jan 1531	XI	38.7	—9.2	approximate	113	
13	E04	2	881	XI	37.5	—8.0	uncertain	15	
13	E05	3	27 Dec 1722	XI	37.1	—7.7	approximate	170	
13	H03	5	23 Apr 1909	X	37.8	—8.9	acceptable	990	
14	E09	3	5 Apt 1504	XI	37.4	—5.6	approximate	86	
15	D12	3	Jan 1494	X	36.7	—4.4	approximate	85	
15	D13	4	25 Dec 1884	X	37.0	—3.8	acceptable	670	
15	D13	6	29 Mar 1954	(m = 7.5)	37.0	—3.6	acceptable	3052	h = 652
15	D15	3	19 Apr 1550	X	36.8	—2.5	approximate	116	
16	K11	3	18 Dec 1395	XI	39.0	—0.6	uncertain	60	
17	M29	3	20 Oct 1654	X	40.0	+4.1	approximate	146	
18	B02	3	1 Nov 1755	XI	36.0	—9.0	uncertain	190	
19	A09	5	21 Jan 1909	X	35.5	—5.6	approximate	969	
21	B19	3	23 Oct 1790	X	35.7	—0.6	approximate	278	
22	C23	6	9 Sep 1954	X	36.1	+1.5	acceptable	3068	m = 6.8
22	C24	4	15 Jan 1891	X	36.5	+1.8	approximate	721	
22	B27	5	24 Jun 1910	XI	36.0	+3.2	acceptable	1055	

SD = Seismic data, see References.

of Table V. In brackets are written the estimated values for several intermediate cases for which no information is available. The probable frequency for 50 years, from the applied formula, or percentage, is not adequate for deducing directly the return period, because these periods should be affected by weithing and thus they would be lower than those shown in above mentioned Table V.

Table V – Probable return period for every region.

Region	VII (60)	VIII (160)	IX (660)	X (1360)	XI (2360)	Remarks
1	30	—	—	—	—	
2	60	—	—	—	—	
3	60	160	—	—	—	
4	8	23	(133)	453	2360	(133) estimate
5	60	—	—	—	—	
6	30	160	—	—	—	
7	60	160	—	—	—	
8	—	—	1360	—	—	uncertain
9	30	—	—	—	—	
10	30	80	220	680	—	
11	15	53	660	(1366)	2360	(1366) estimate
12	(33)	160	—	—	—	(33) estimate
13	(18)	(91)	(453)	1360	1180	( ) estimate
14	60	(216)	660	—	—	(216) estimate
15	7	15	330	453	—	
16	5	33	330	(872)	2360	(872) estimate
17	—	—	—	1360	—	uncertain
18	60	160	330	—	—	
19	30	160	(627)	1360	—	(627) estimate
20	10	160	660	—	—	
21	30	(108)	330	1360	—	(108) estimate
22	5	9	220	680	—	
area	0.9	3	39	91	337	

In order to check these results by means of the actual intervals, we have computed the return periods from the first up to last earthquakes included in the information, for each intensity degree:

I_0	ordinal first	last	interval years	occurred shocks	return period
XI°	881	1910	1029	7	145
X°	949	1954	1005	16	63
IX°	1420	1887	467	17	28
VIII°	1804	1960	164	53	3
VII°	1908	1960	52	68	0.8

The comparison of these results with those of Table V gives a complet conformity for VII° and VIII° small differences for IX° and for the highest degrees, values separated, approximately, a 30 percent for X° and 57 percent for XI dg, respectively. We think, this is a confirmation of the assumption discussed in EF about a restrictive criterion for classifying the great earthquakes corresponding to old epochs; perhaps they were classified between one and two degrees too low. Thus, we believe it is reasonable to accept the following as probable and approximate values for the return period of the destructive earthquakes, for the whole investigated area,

intensity	=	VII	VIII	IX	X	XI	(degrees)
return	=	1	3	30	80	240	(years)

This list suggests, only as an approximate probability, a violent earthquake to be espected in the area during a half of a century.

Final note.

This paper is continuation of the seismic studies on the Peninsula Iberica area and will be followed by other treating the liberated energy and seismic flux. This report has been subsided by the Air Force Office of Scientific Research, OAR, through the European Office of Aerospace Research of United States Air Forces, contract AF 61 (052)–657, as part of the Advanced Research Project Agency's Project VELA-UNIFORM.

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