

From historical earthquake records to intensity value: some results of a study

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Abstract

The use of historical records to assess macroseismic intensity involves problems seldom evidenced. This paper deals with the problems connected with the use of macroseismic scales, with particular attention to MSK 81 and the EMS 92, in the case of two Italian localities (Fabriano in the Marche region and Orciano in North-Western Tuscany) damaged by two earthquakes (1741, April 24 and 1846, August 14) which have a good historical documentation. Nevertheless, it is difficult to obtain the data required by the scales. It follows that intensity estimates are in principle affected by some uncertainties which have been analysed.

Key words *Fabriano, Orciano (Italy) – macroseismic intensity – macroseismic scales – historical earthquake records*

1. The problem

During the last few years, the use of historical earthquake records has considerably increased. Since these data offer the possibility to cover quite a long time-window they can be used as a relevant resource for the evaluation of seismic hazard (Stucchi, 1991; Guidoboni and Stucchi, 1993).

Unfortunately, this re-evaluation of historical earthquake records was only partially followed by a real understanding of the interpretative problems connected with their utilisation as well as their informative richness, which could allow wide utilisation in various fields.

However, the attention towards the problems connected with the use and the interpretation of these data has recently increased. In fact, it seems more and more difficult to force the historical data into the traditional procedure to assign catalogue parameters. The use of his-

torical documentation has thus developed, improving procedures and analysis methodologies as well as the intervention of historians.

These researches are the starting point of the process leading to the compilation of catalogues and most users know and use historical earthquake data as catalogue records (Stucchi, 1993). The catalogues are then a «concentrated» source of historical information employed by users who often do not know either the characteristics or the processing of data.

The compilation of a catalogue entry is the last step of a process that starts by individuating the sources, analysing their information, locating them in time and space and interpreting them to assess the intensity value (fig. 1). This last procedure – assessing intensity value – is tackled in this paper in order to analyse the problems arising while assessing macroseismic intensity from historical earthquake records, and to verify which procedures must be followed to exploit the informative richness of historical data.

The discussion will be limited to Fabriano

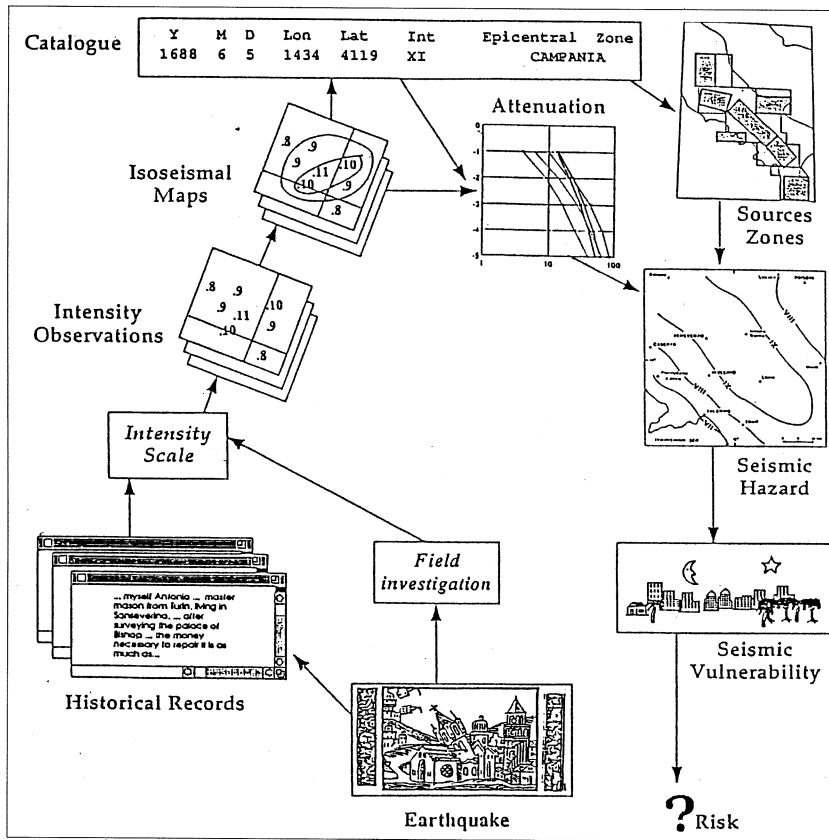


Fig. 1. General scheme of processing and using macroseismic data (from Stucchi, 1993).

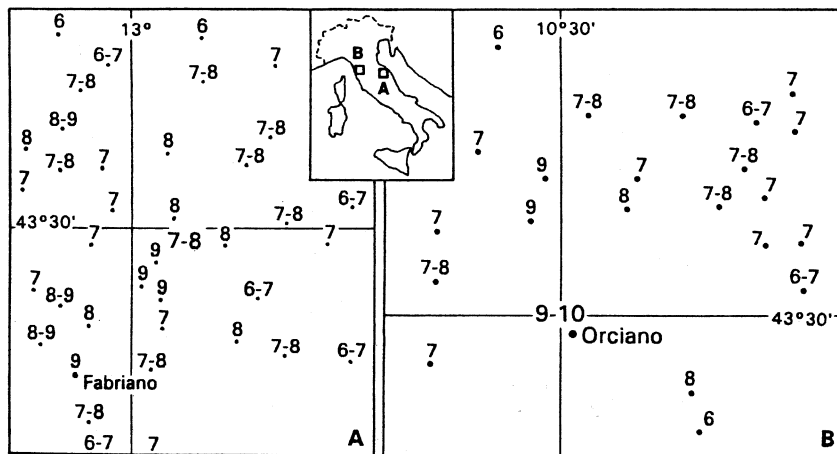


Fig. 2. A) The 1741, Fabriano earthquake (intensity from Stucchi *et al.*, 1991); B) the 1846, Orciano earthquake (intensity from Albini *et al.*, 1991).

(Marche region) and Orciano (North-Western Tuscany), the two most damaged localities of April 24, 1741 ($I_0 = IX$ according to Postpischl, 1985) and August 14, 1846 earthquakes ($I_0 = X$ according to Postpischl, 1985) (fig. 2).

The MSK 81 scale and the new EMS 92 one (still at the experimental stage, Grünthal, 1993) will be used. Both these scales can be represented as a series of tables, formed by the distribution of percentages of damaged build-

ings – divided according to types of structures – in the classes of damage (fig. 3). Therefore, to assess an intensity value means elaborating the macroseismic data into a table and then verifying their correspondence to one of the theoretical distributions of the scale (fig. 4). The problem is to identify the relation between the scale and the real data and if the scale is a good instrument to process earthquake historical records.

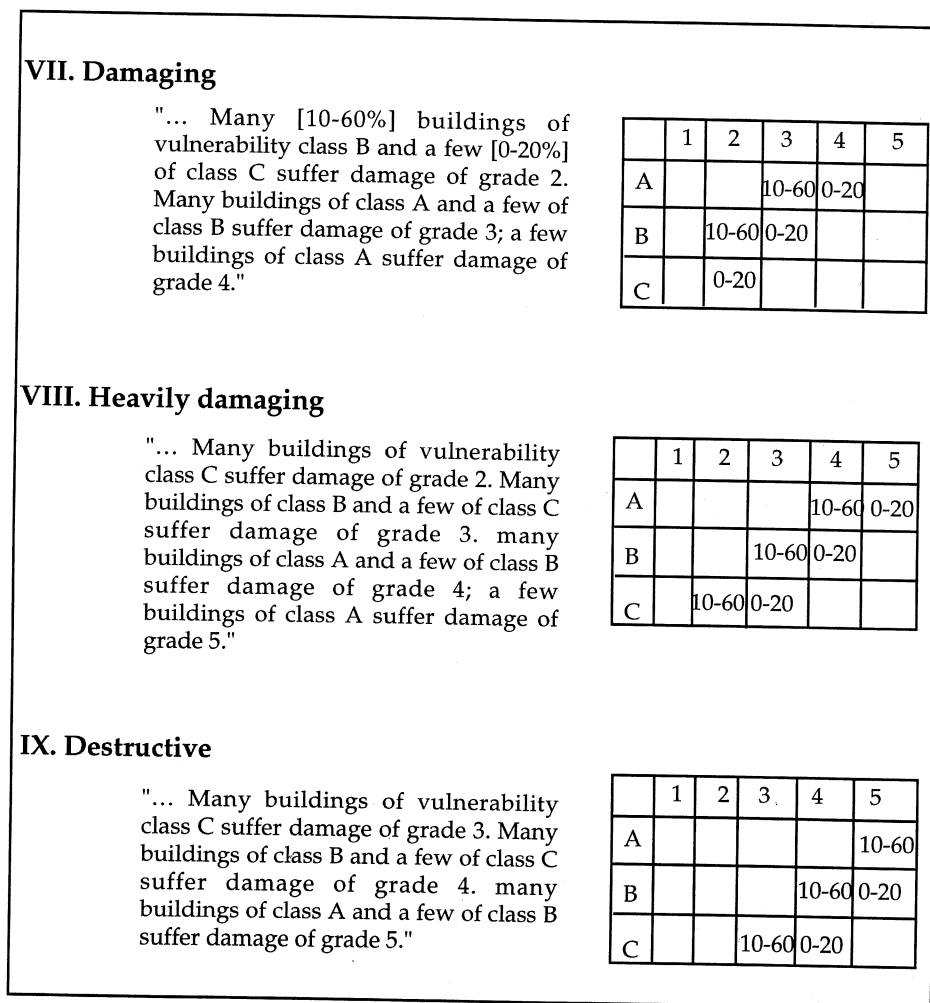


Fig. 3. EMS definitions of intensity degrees and table representation (only degrees VII, VIII and IX, and buildings of vulnerability classes A, B and C).

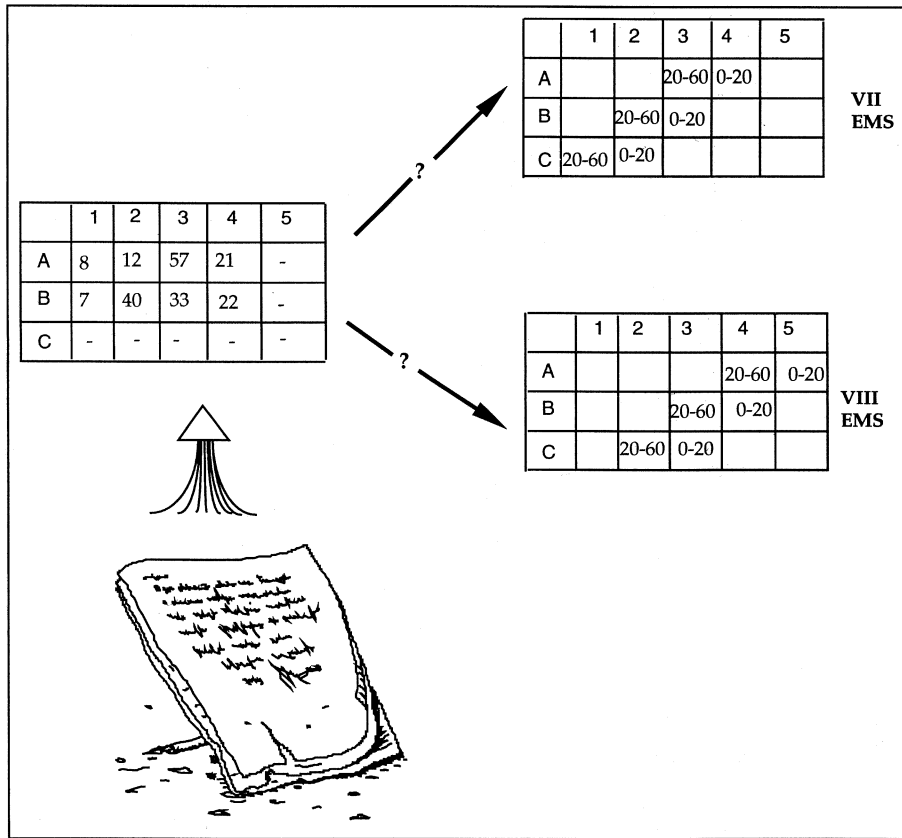


Fig. 4. Scheme of the processing of earthquake historical records from the source to the intensity estimate.

2. The sources of the Italian Catalogue

The repertories compiled in the last centuries are some of the sources most used by the Italian Catalogue (Postpischl, 1985). These compilations mainly use published sources. One of the richest in information is Baratta (1901) who, about the 1741 earthquake, reports that Fabriano was the most damaged locality and that «the majority of its buildings was knocked down». The description of Baratta involves many difficulties when MSK and EMS scales are employed. In fact, Baratta does not report any information either about the typologies of the buildings or the distribution of dam-

age comparable with the 5 classes of the scales.

So, we must proceed by advancing some hypotheses. Supposing buildings were A or B type and damage was heavy, corresponding to class 4 or 5, a table with this distribution of data will be obtained:

	1	2	3	4	4/5	5
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A						
A/B					75%	
B						

The information reported by Baratta supplies only two extreme scenarios. The two hypotheses are: the first, most conservative, assumes the highest degree of damage and the lowest vulnerability (B-type); the second, less conservative, assumes the lowest degree of damage and the highest vulnerability (A-type). These hypotheses are extreme, but since more detailed information is missing, it is not possible to say what the reality is; it is possible only to say that the intensity value for this locality is between the two extremities, that is to say between VIII and XI MSK, or between VIII and XI EMS (fig. 5).

The Italian Catalogue assigns $I_0 = X$ MCS to the 1846 earthquake. The catalogue quotes Baratta (1901) who used Pilla (1846) as source for this event. This author was an eye witness. He also reports some information which can be used for assessing building typologies: most of the Orciano buildings were badly constructed;

the most firm buildings «are erect on their foundations, even if cracked or damaged», while «peasant houses are all in ruins». Using MSK scale it is possible to suppose that «peasant houses» were of A-type and the other ones were of B-type. Figure 6 shows how the data have been processed in order to assess the macroseismic intensity in the two extreme hypotheses. In this case it must be stressed that, using EMS scale, the relation between the theoretical distributions of damaged buildings in the classes of damage and those drawn up using Pilla's report, is more coherent than using MSK scale.

In both cases the sources present generic information about the typology of buildings and the damage. Because of these uncertain data, the intensity ranges between one or three grades. In order to improve this situation, more detailed historical sources have been investigated.

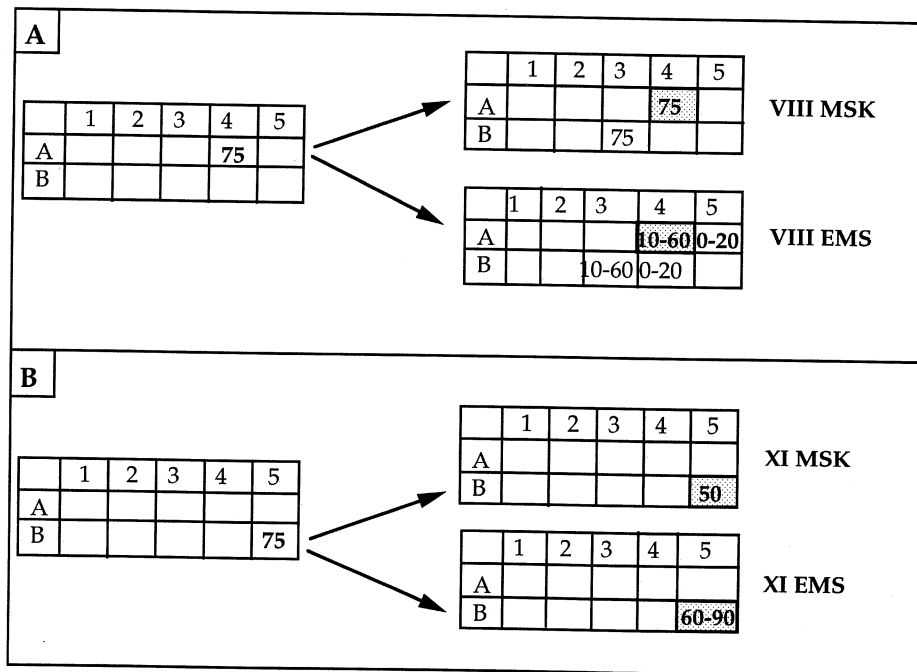


Fig. 5. MSK and EMS intensity assessment for Fabriano from Baratta (1901) in the less conservative case (A) and in the most conservative one (B).

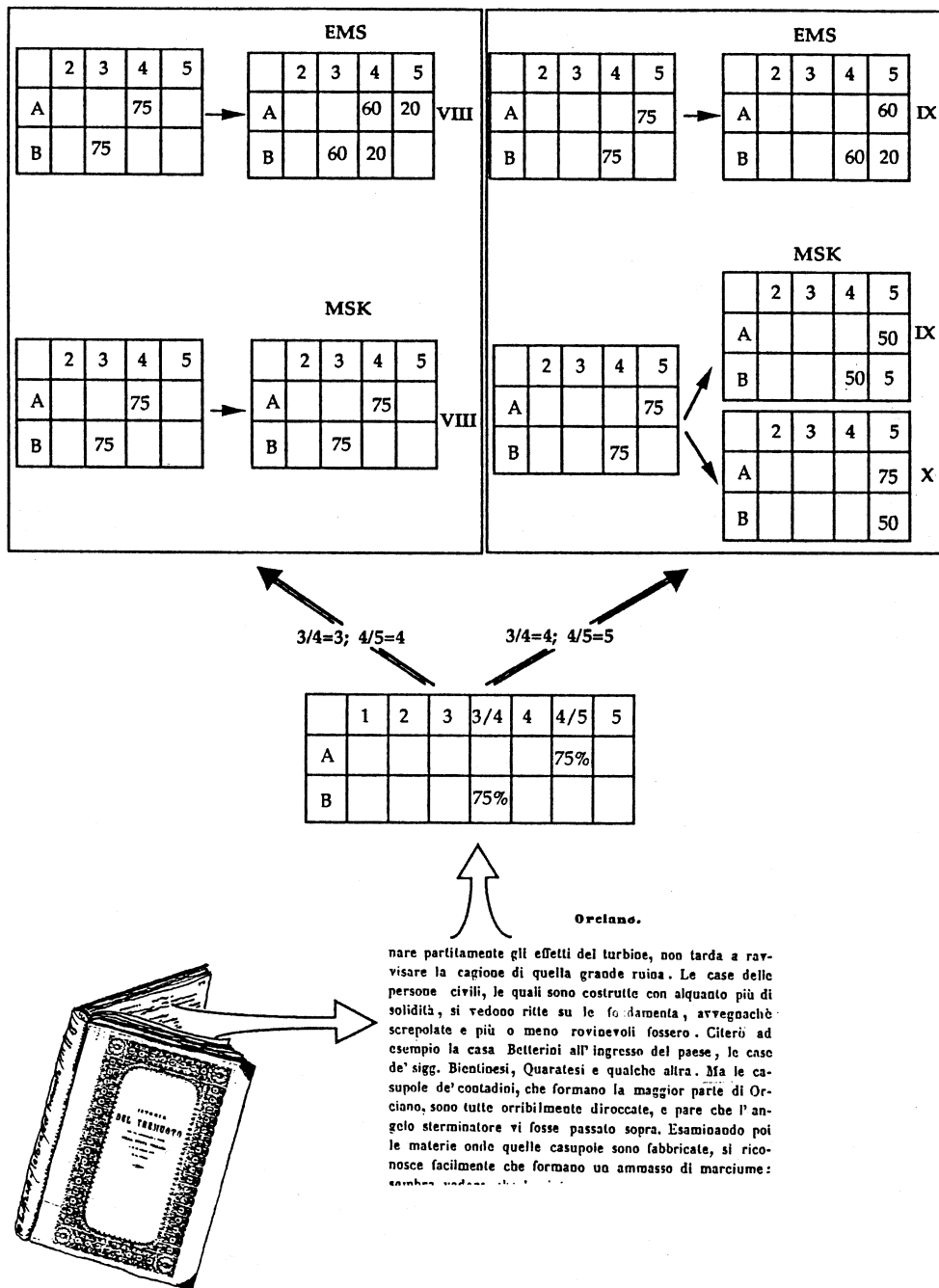


Fig. 6. Distribution of Orciano data from Pilla (1846) in a table; MSK and EMS intensity assessment in the less conservative case and in the most conservative one.

3. Archival sources

Both after the 1741 earthquake and the 1846 one, the governments of two States (the State of Church and the Grand Duchy of Tuscany) surveyed the damaged buildings, so it is possible to know the effects of these earthquakes through the analysis of the detailed documentation produced by the governments (ASRm, 1741; ASPi, 1846). However, the sources for both earthquakes do not supply data on the types of structure and the damage descriptions do not always allow clear grading of damage (Monachesi and Moroni, 1993). For many cases, where a clear classification was impossible, it was decided to keep them as uncertain (A/B-type and 3/4 class of damage, to say that these buildings could be either A or B and damage 3 or 4).

Table I shows the distribution of data according to types of structures and classes of damage for both the localities. For 20% of Fabriano buildings and the 23% of Orciano ones an uncertain typology was assigned (A/B type), while in 58% of Fabriano cases and in 47% of Orciano ones it was impossible to identify one of the classes of damage of the

scales in the damage description. In these cases an uncertain class was assigned (3/4, or similar).

This uncertainty of historical data is reflected in the intensity estimates. The goal is then of verifying if these data, more detailed than those supplied by Pilla and Baratta, can reduce the range between the two extreme intensity values.

Figure 7A shows the MSK value for Fabriano: in the most conservative case the distribution of damaged buildings in the classes of damage corresponds to that of IX MSK. In the less conservative case the results are contradictory. In fact, the distribution of A-type buildings in the classes of damage corresponds to VII MSK. On the contrary, the distribution of B-type buildings can correspond either to VIII MSK (many buildings with damage 3) or to IX MSK (a few buildings with damage 4 and 5).

The EMS scale supplies a slightly different result (fig. 7B). In the most conservative case the distribution of damaged buildings in the classes of damage corresponds to the IX EMS. In the less conservative case the result is still uncertain but less contradictory than using the MSK scale. In fact, the distribution of A-type

Table I. Distribution of Fabriano and Orciano data.

	Fabriano (1741)				Orciano (1846)			
	A	A/B	B	Total	A	A/B	B	Total
No damage			70	70	-	-	1	1
1	0		1	1	-	-	-	-
1-2	0		6	6	1	1	1	3
2	0	10	33	43	-	-	1	1
2-3	0	28	77	105	-	3	2	5
2-4	0	5	12	17	-	3	-	3
3	0	14	121	135	1	1	12	14
3-4	0	78	237	315	-	2	6	8
3-5	0		5	5	-	-	1	1
4	0	26	59	85	-	2	14	16
4-5	0	8	26	34	1	4	8	13
5	0	6	11	17	-	-	3	3
Total	0	175	658	833	3	16	49	68

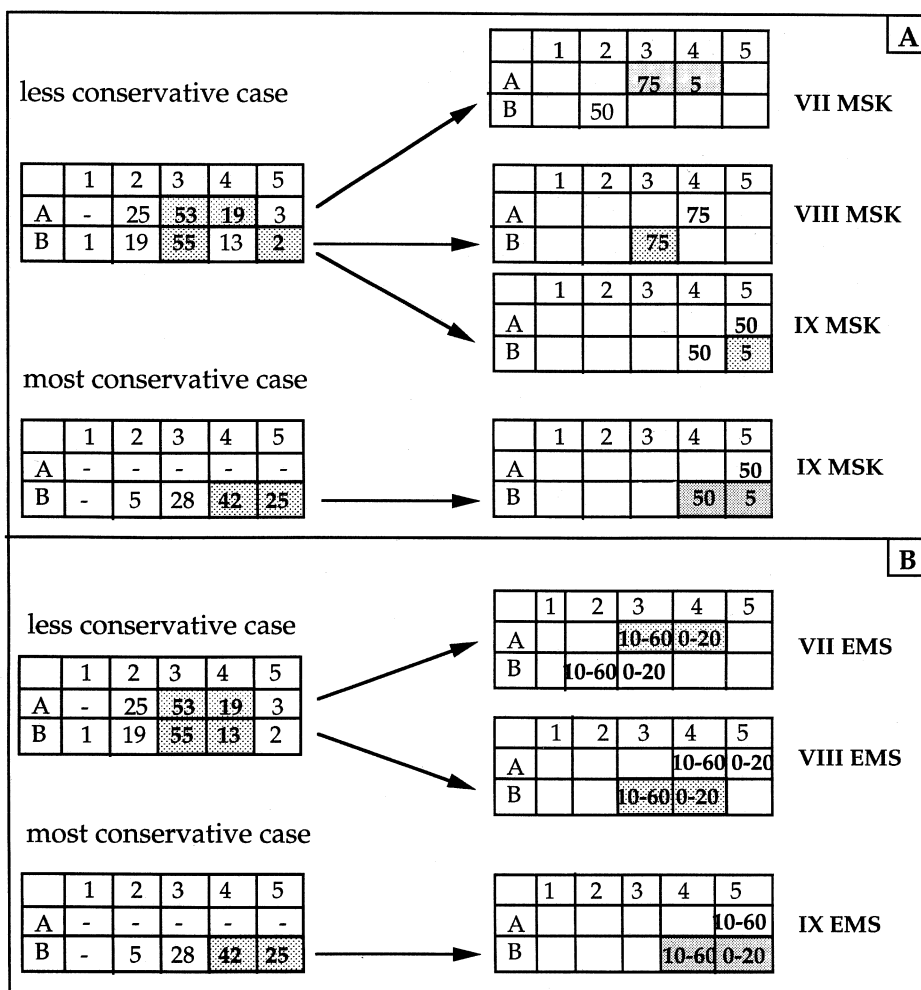


Fig. 7. Intensity assessment for Fabriano from ASRm (1741) in the less conservative case and in the most conservative one. A) MSK intensity estimates; B) EMS intensity estimates.

buildings corresponds to VII EMS and that of B-type corresponds univocally to VIII EMS.

Figure 8 shows the results in the Orciano case. The MSK value ranges between VII and IX. Also for this locality the less conservative scenario is highly contradictory (the A-type distribution corresponds to VII and VIII MSK, B-type distribution corresponds to IX MSK). The EMS value ranges between VIII and IX with an uncertainty in the less conservative

case (A-type distribution corresponding to VIII EMS and the B-type distribution corresponding to IX EMS).

Summarising, in the case of Fabriano the MSK value ranges between VIII and XI using the data coming from Baratta's report and ranges between VII and IX using the data coming from archival documentation. The EMS value ranges between VIII and XI using Baratta and between VII and IX using archival

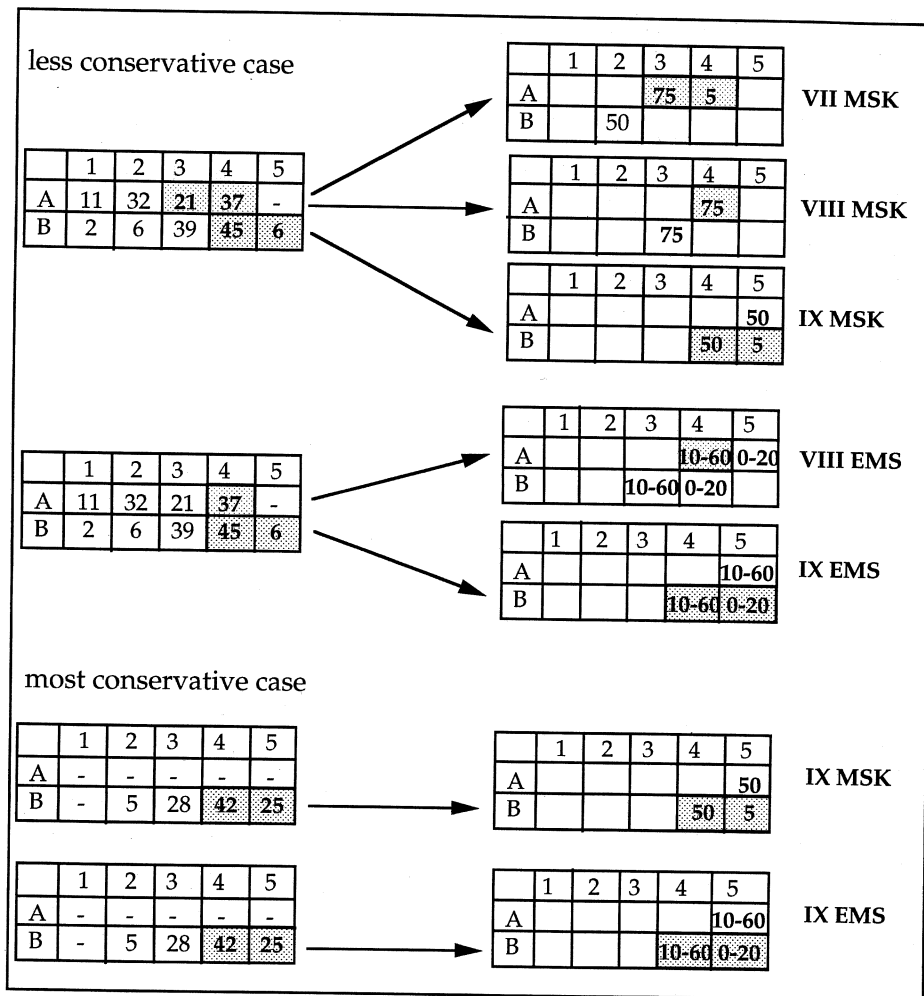


Fig. 8. MSK and EMS intensity assessment for Orciano from ASPi (1846) in the less conservative case (A) and in the most conservative one (B).

documentation. The generic information present in Baratta's report produce an uncertainty of 3 degrees (using both MSK and EMS scale). The resort to the more detailed archival documentation reduces the uncertainty to 2 degrees (using both the scales).

In the case of Orciano the MSK value ranges between VIII and X using data coming from Pilla's report and between VII and IX using the data coming from archival documenta-

tion. The EMS value ranges between VIII and IX using either Pilla's report or archival documentation. In this case the quite good information coming from Pilla (1846) produces an uncertainty of 1 degree, the same range obtained using archival documentation. It must be stressed that, in the case of Orciano, the EMS scale seems to be able to process the historical records better than the MSK; in fact, the EMS value is less uncertain than the MSK one (fig. 8).

4. Conclusions

Neither Baratta's nor Pilla's reports deal with enough elements to assign univocal intensity values. A careful reading of the source reports and a rigorous application of the scales determine different values for Fabriano (VIII-XI MSK and VIII-XI EMS) and Orciano (VIII-X MSK and VIII-IX EMS).

In the case of Orciano using more detailed sources (ASPi, 1846) the intensity values decrease; in the case of Fabriano using archival sources (ASRM, 1741) the range between the two extreme values decreases, but does not disappear. For both cases the historical data do not permit an univocal intensity value to be assigned, but it is always possible to distribute the percentages of damaged buildings both in a table corresponding to the less conservative case, and in another one corresponding to most conservative case. Probably an improvement could come from new information about historical typologies of buildings, but the research of this kind of data requires much time and many resources.

For both earthquakes the historical records permit two or more intensity values to be assigned. The user of these macroseismic intensities must choose one of these values and explain the reason for his choice. A different way could be that of devising new algorithms, which could process historical records keeping to the information contained in them. But until then, it would be a mistake to hide the uncertainties coming from historical data.

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