

The new «Catalogue of Strong Italian Earthquakes»

Enzo Boschi, Paolo Gasperini(*), Giuseppe Smriglio and Gianluca Valensise
Istituto Nazionale di Geofisica, Roma, Italy

Abstract

We describe a new catalogue of strong Italian earthquakes that the Istituto Nazionale di Geofisica in collaboration with SGA, has recently made available to the international scientific community and to the general public. The new catalogue differs from previous efforts in that for each event the usual seismic parameters are complemented by a list of intensity rated localities, a complete list of relevant references, a series of synoptic comments describing different aspects of the earthquake phenomenology, and in most cases even the text of the original written sources. The printed part of the catalogue has been published as a special monograph which contains also a computer version of the full database in the form of a CD-ROM. The software package includes a computer program for retrieving, selecting and displaying the catalogue data.

Key words *historical seismology – earthquake catalogues – Italian seismicity*

1. Introduction

Traditional seismic catalogues represent each earthquake with a single computer record specifying in numerical form its origin time, its location and its associated energy. These catalogues, which we may call *parametric*, have long been used in many countries, and in most cases still are. In the past few years, however, there has been growing consensus that this format is no longer adequate to the needs of modern seismic hazard studies (e.g. Bellani *et al.*, 1989; Postpischl *et al.*, 1991). Nevertheless limited efforts have already been made towards the rationalization of the historical earthquake data and their reorganization in a comprehensive database including all the information that was used to determine the parameters themselves, such as the list of the locations for which the intensity was determined and the

text of any available original sources (Bergamaschi *et al.*, 1981; Stucchi, 1990).

In the past, the two main obstacles to the creation of such a database were the high cost of transferring onto computer media large amounts of documental material and the lack of standard criteria and formats in the assessment of earthquake effects. A wide bibliography of studies is in fact available for most of the major Italian historical earthquakes, but all of these studies are based on different approaches and methodologies and hence are not homogeneous. This condition may lead to significant difficulties and misinterpretations, for instance when the analysis of the historical data is performed without an adequate background on the historical lexicon; when different workers use different scales without explicitly stating it, or use different macroseismic interpretations for the rating criteria of the same scale; when the seismic response of historical buildings is not properly assessed; or finally, when the distribution of intensities is only given in the form of a hand-drawn isoseismal map. The availability of a homogeneous and complete computer database of historical seismicity data would certainly help reducing these

(*) *Present address*: Dipartimento di Scienze della Terra, Università di Firenze, Italy.

and other potential sources of uncertainty. It would also represent a giant leap for research in historical seismology, something similar to the big change triggered by the introduction of digital waveform recording and analysis techniques in instrumental seismology.

A research tool like this would indeed offer many advantages. First of all, anyone would be given the opportunity to access firsthand historical information, which would make any reevaluation of the data in the light of new assumptions and/or interpretative models much easier. The researcher would no longer be forced to accept previous interpretations of the data, much in the same way as a seismologist can now easily re-read arrival times from digitized waveforms instead of accepting existing routine pickings. The data could be straightforwardly and more objectively analyzed using modern computer techniques (for example see the work by Ferrari *et al.*, 1995), and there would exist a clear record of the progressive improvements to the original dataset. Finally, thanks to the power and capabilities of modern computers, even large datasets could be easily exchanged via computer network or media.

2. Yet another catalogue?

Starting in 1987 the Istituto Nazionale di Geofisica (ING) has promoted several studies to gather and rationalize any type of information on all the large Italian earthquakes that have left significant traces in the historical record. These studies were commissioned to *Storia Geofisica Ambiente* (SGA), a private firm based in Bologna that specializes in historical research into various types of natural phenomena. This effort has led to the publication of several large bodies of historical research on earthquakes that have occurred in Italy and in the Central and Eastern Mediterranean over the past two millennia. The most recent publication is that of the «Catalogue of Ancient Earthquakes in the Mediterranean Area up to the 10th century» (Guidoboni *et al.*, 1994), a systematic and thorough revision of the strongest earthquakes of the first millennium. This work is based on many written

sources most of which are reported in their original form and language. The forthcoming book «I Terremoti Distruttivi della Calabria e della Sicilia, Secoli XVI-XX» (Guidoboni *et al.*, in preparation) presents a detailed and comprehensive analysis of all the earthquakes having maximum intensity larger or equal to degree VIII that have occurred in the two most active regions of Italy during the past five centuries.

In 1991, ING and SGA started developing PERSEUS (Boschi *et al.*, 1992), a powerful computer database that would ensure quick access to the history of seismicity of any area struck by a strong earthquake. PERSEUS was originally designed to assist the Italian Civil Defense in the process of decision-making following a large earthquake, but soon became an essential tool for routine investigations on Italian seismicity by ING researchers. During its development all the information made available from previous studies, including all the intensity rated points, the comments produced to describe different aspects of each earthquake and the damage suffered by any struck locality, and in some cases even the text of original documents that were used to assess the earthquake effects, was transferred on computer media, for a total of over 100 Mbytes. The system was based on a GIS (Geographic Informative System) capable of displaying the location and the effects of the largest Italian earthquakes in relation with the country's topography, distribution of towns and villages, and political boundaries. Owing to the complexity of its structure and to the large number of the tasks it was expected to perform, PERSEUS was implemented on a Sun workstation aided by a large electrostatic plotter. The system became operational at the ING at the beginning of 1993.

During the following six months PERSEUS generated significant attention in the national and international scientific community, such that in June 1993 the ING decided to derive a simplified version of the database. The new product, which is now published (Boschi *et al.*, 1995), was termed «Catalogue of Strong Italian Earthquakes», takes advantage of the rapidly increasing capabilities of small personal computers and therefore is made easily available to a

much broader audience than its father system. Compared to PERSEUS the new catalogue uses a simplified, non-geographical approach for selecting earthquakes and localities of interest, but it also emphasizes much more than its predecessor the friendliness of the various tools and commands and the rapidity of retrieval and processing of the information. Nevertheless the new catalogue retains three main qualities that already characterized PERSEUS:

a) it is a *new generation catalogue*, since for each earthquake it reports not only the standard synthetic seismological parameters but also the original texts used for analyzing its effects, synoptic comments by the compilers, and data on the demography, on the characteristics of the territory and of the buildings of the involved areas;

b) it is a *dynamic catalogue*, since any progress in basic historical investigations will be included in future releases. Each new release will summarize the progressive evolutionary stages of the database. The catalogue is open to the contribution of all the investigators in historical seismology who want to join this new effort and make available the results of their research to everyone;

c) it is a catalogue devoted to *strong earthquakes*, that is, all the earthquakes that have had significant effects from both geodynamic and socioeconomic points of view. This characteristic must be regarded also as a *priority criterion* for selecting earthquakes to be investigated with special emphasis in preparation for their inclusion in the catalogue.

The need for a catalogue of *strong earthquakes* is a direct consequence of Gutenberg and Richter's (1956) magnitude/frequency-of-occurrence law, which states that the number of earthquakes in each class of earthquake magnitude increases approximately tenfold when the magnitude decreases by one unit. In most types of seismic hazard analysis the completeness of the earthquake data over a certain period of time is a fundamental requirement, but this condition may lead to consider too many earthquakes if the selected magnitude threshold is too low. On the other hand, the en-

ergy-magnitude (Gutenberg and Richter, 1956) and moment-magnitude (Hanks and Kanamori, 1979) laws and the *Characteristic Earthquake* concept (Schwartz and Coppersmith, 1984) indicate that, for a given seismogenic region, a few of the strongest earthquakes release most of the stored energy or seismic moment, such that studying a limited number of large events is generally sufficient to set the framework of a region's seismic release.

While the large number of moderate size earthquakes that occurred in Italy may have induced the compilers of previous catalogues to somehow neglect the larger ones, our new catalogue was conceived and specifically designed to proceed from the «top» to the «bottom» of the Gutenberg-Richter pyramid, so that larger earthquakes are given more importance than smaller ones. The first version of the catalogue contains only earthquakes that were reported in the «Catalogo dei Terremoti Italiani dall'Anno 1000 al 1980» of the Progetto Finalizzato Geodinamica (Postpischl, 1985) with a maximum intensity larger than (but not equal to) degree VIII of the MCS scale, which also includes events having uncertain intensity between VIII and IX. In particular, the catalogue contains:

1) large earthquakes that occurred in Italy before the year 1000. These were accurately studied by ING and SGA between 1988 and 1994 (Guidoboni *et al.*, 1989, 1994) (87 events);

2) all the largest earthquakes that have occurred in Sicily and Calabria during the past five centuries. These were accurately studied by ING and SGA between 1990 and 1994 (Guidoboni *et al.*, 1995) (57 events);

3) all the earthquakes that were studied in preparation for the selection of nuclear sites. These studies were commissioned by ENEL (the Italian electric power agency) between 1983 and 1987 (about 100 events);

4) all the earthquakes that were reconsidered in the framework of the PERSEUS project (Boschi *et al.*, 1992) (about 120 events).

Having been studied at different times, for different purposes and under the appointment of different agencies, the earthquakes that ap-

pear in the catalogue do not all exhibit the same level of detail. This condition can be summarized by reference to two main categories or standards of research completeness. In the first category, which we refer to as *accurate*, the information supplied includes synoptic comments for each locality, summary comments concerning the demography, building practice and distribution, political events, the natural and social environments at the time and in the region of the given earthquake, and any other aspect which may be relevant to the full understanding of its effects. *Accurate* investigations are complemented by reference cards describing all the sources of information on which the research is based and their availability and a collection of original texts. Studies falling under the second category, which we refer to as *expeditious*, supply only synoptic comments and reference cards for each earthquake. All of the earthquakes under the headings (1) and (2) (see above) were studied following *accurate* standards. Being especially focused on the safety of specific nuclear power plants, the study of each of the earthquakes investigated under the heading (3) was in part *accurate* and in part *expeditious* following a geographical criterion. All of the remaining earthquakes (heading (4)) were studied according to the *expeditious* standards.

The first version of the catalogue contains 346 earthquakes, but new historical investigations are already underway to expand the database. The new investigations have two main targets:

- extending the database to include all the earthquakes of intensity VIII and lower. This will require a specific *expeditious* study for each new earthquake. For instance, about 150 earthquakes with epicentral intensity VII-VIII and VIII that occurred in Italy were investigated between 1994 and 1995 and are scheduled to be published in 1996;

- re-investigate large and especially significant or controversial earthquakes that have been studied only expeditiously. Under this project the 9 September 1694 earthquake, a large event that devastated the same region struck by the 1980 Irpinia earthquake, will be re-analyzed in detail between 1994 and 1995.

In all cases the new investigations will be completed with the same approach and standards used for all the previously studied events, so as to preserve the consistency and homogeneity of the database.

3. Structure of the catalogue

The catalogue is distributed on a CD-ROM (Compact Disc Read Only Memory) using the ISO-9660 format. We believe this choice is especially convenient based on several considerations:

- 1) the high capacity of the CD medium (up to 650 Mbytes), which allows the whole database to be included on a single disk;

- 2) the fact that Compact Discs using the ISO-9660 format can be handled by virtually all the most common operating systems, so that different applications developed for different platforms can be distributed using the same physical medium;

- 3) the wide diffusion of the CD-reading units in the seismological community, which is partially due the fact that this medium is the same adopted by the main international agencies for the distribution of instrumental earthquake data;

- 4) the convenience of the medium itself, which is light, strong, virtually incorruptible and extremely inexpensive;

- 5) the read-only nature of the medium, which makes it the perfect choice for releasing reference data.

The data are supplied to the users in the form of a database file of OMNIS 7.3, a DBMS (Data Base Management System) manufactured by Blyth Software Ltd. This is the same DBMS that was used originally for the production of the catalogue database, a condition that simplifies things significantly as most of the management software is already available and has been repeatedly tested through everyday use. A specific application was written to allow the user to select, display and print specific portions of the database. The applica-

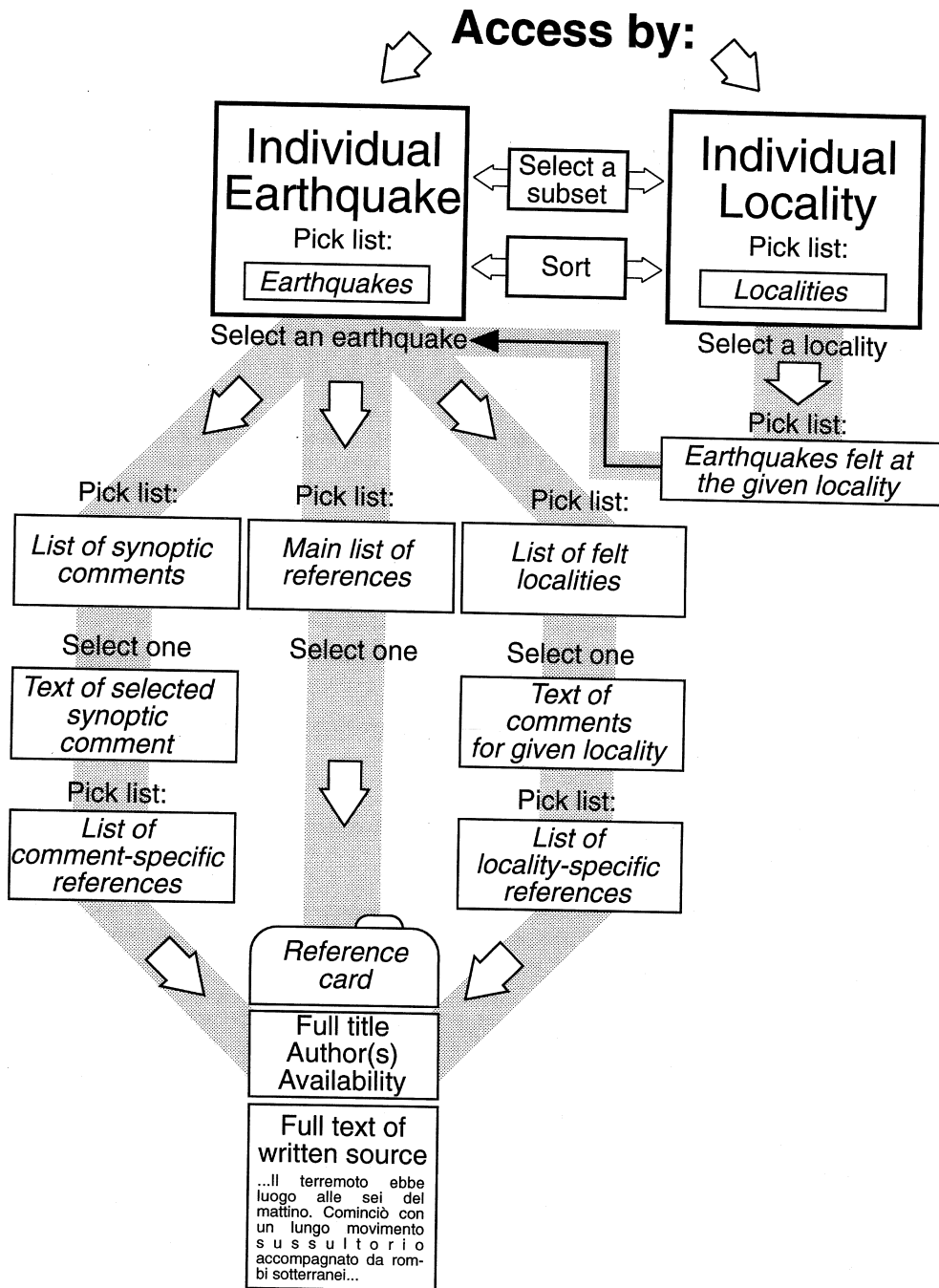


Fig. 1. Flow chart of the application that has been developed for retrieving, selecting and displaying the catalogue data.

tion, which has exactly the same functionality under both MS-Windows and Macintosh, is also included in the CD. Given the non-commercial nature of this effort, the ING has been able to make a special agreement with Blyth Software Ltd. such that the DBMS and the associated application could be reproduced for about 2000 copies at virtually no additional cost.

Access to the data takes place in a menu-driven environment following two main modes: «by earthquake» and «by locality». Figure 1 outlines the different paths and options offered by each access mode. Figure 2 shows the main window displayed after choosing the access «by earthquake». The main window includes four scrolling pick-lists displaying the full earthquake list, the title of all the available synoptic comments, the author and ti-

tle of all the available references, and the list of localities where the earthquake was reportedly felt. Initially only the first of these pick-lists is effectively filled with data. This list contains all the events included in the database and summarizes their main parameters:

- origin time;
- epicentral coordinates and epicentral zone;
- epicentral intensity and equivalent magnitude;
- number of felt localities;
- level of the investigations (*accurate* or *expeditious*).

The earthquake list can be modified to include only events selected on the basis of space, time or intensity criteria using the *Selec-*

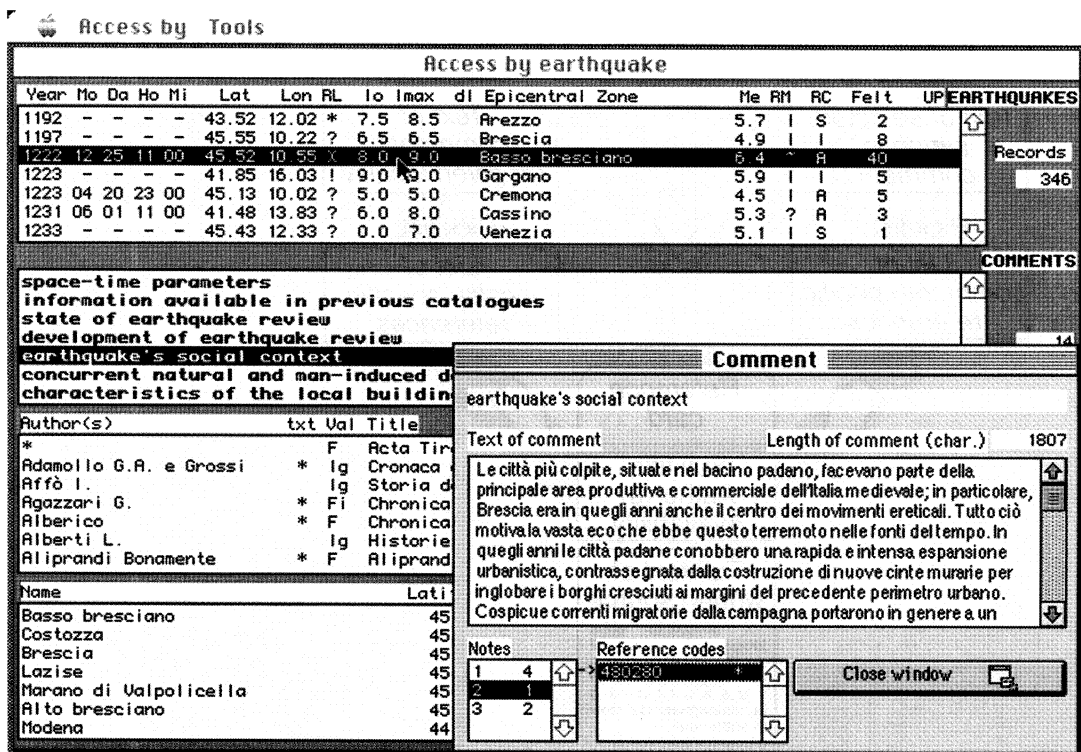


Fig. 2. Screen display of the catalogue: access by individual earthquake. The display shows all the information associated with the earthquake of 25 December 1222 in the Brescia area.

Access by Tools

Access by locality

Name	Lat	Lon	Felt	see also	LOCALITIES
Montemurro (PZ)	40.297	15.991	12		↑
Montenars (UD)	46.256	13.181	3		
Montenero Val Cocchiara (IS)	41.717	14.068	1		
Montenero di Bisaccia (CB)	41.956	14.781	1		
Montenerodomo (CH)	41.975	14.252	2		
Monteodorisio (CH)	42.086	14.652	1		
Monteoliveto Maggiore (SI)	43.175	11.545	1		↓

Records 8230

Year	Mo	Da	Ho	Mi	Lat	Lon	Io	Int	Epicentral Zone	Me	RC	FELT REPORTS
1836	11	20	07	30	40.17	15.88	8.0	7.5	Basilicata meridionale	5.5	A	↑
1857	12	16	21	15	40.37	15.83	11.0	11.0	Basilicata	7.0	A	
1857	12	26	05	00	40.30	15.98	7.5	7.5	Montemurro	5.3	A	↑
1887	12	03	03	45	39.53	16.17	8.0	4				12
1894	11	16	17	52	38.28	15.88	9.0	4				
1905	09	08	01	43	38.67	16.05	10.0	6				
1910	06	07	02	04	40.97	15.30	8.5	5				

reconstructions, relocations
associated natural phenomena
major earthquake effects
effects by individual locality
effects on the environment
location and nature of the observ
full chronology of the earthquake

Author(s)	txt	Val	Titl
Arcane G.	*	St	Notiz
*	*	F	Arch
*	*	F	Arch
*	*	F	Arch
*	*	F	Arch
*	*	F	Arch
*	*	F	Arch

Montemurro

effects by individual locality

Text of comment Length of comment (char.) 537

Il terremoto causò la completa distruzione dell'abitato. Il paese fu ridotto ad un cumulo di macerie: quasi tutti gli edifici crollarono completamente. Ci furono circa 5000 vittime e circa 900 feriti. Gli ultimi resti di costruzioni furono abbattuti da due forti repliche avvenute il 26 dicembre 1857 (1). Rimasero in piedi solo un palazzo e il convento dei Frati Minori, comunque gravemente lesionati, e tre campanili crollati parzialmente. Divamparono numerosi incendi.

Notes Reference codes

051280	*	↑
120037	*	↑
120120	*	↑
120121	*	↑

Close window

NTS 17 CES 342

Fig. 3. Screen display of the catalogue: access by individual locality. The display shows the information concerning the effects of Montemurro (selected locality) for the earthquake of 16 December 1857 (selected earthquake).

tion facility from the «Tools» menu. By double-clicking the line displaying a given earthquake in the pick-list, all the information contained in the database concerning that event is loaded and the remaining pick-lists are activated. Their informative content can be displayed simply by double-clicking any of their lines. For instance, clicking on *Space-Time Parameters* will display the text of the corresponding synoptic comment. Clicking on any of the *Felt Localities* will open a new smaller window with a summary description of the effects of the given earthquake at the selected locality and a list of relevant reference codes.

The content of selected comments and reference cards can be saved on a file by selecting the *Send to File* option from the «Tools» menu.

The file is stored on the computer disk for any subsequent computer analyses or to obtain printouts.

Due to space limitations, the monograph (Boschi *et al.*, 1995) contains about 10% of the information stored in the CD, and in particular:

- a list of synthetic earthquake parameters with statistics on the number of intensity rated localities;
- the number of reference sources divided by type;
- the complete list of intensity rated localities;
- a selection of the synoptic comments.

Figure 3 shows the main window displayed

after choosing the access «by locality». The publication also includes a manual for proper installation and usage of the catalogue, and a set of articles describing the criteria adopted for gathering, analyzing and formatting the basic information forming the database.

4. Concluding remarks

We hope that the project undertaken by the ING to distribute its entire macroseismic database will have the effect of stimulating larger interest in historical seismology data. The new catalogue will certainly have a large potential audience among the scientists involved in various steps of the assessment of seismic hazard, such as paleoseismologists, microzonation experts and tsunami experts. Nevertheless we believe it may become a useful tool for all those who operate in any of the disciplines straddling human and natural science, such as archaeologists, geographers and architects.

We also hope that many of these scientists will take advantage of the convenience of the computer medium to develop automated procedures that may turn the world of descriptive information contained in the catalogue into quantitative parameters of the earthquake generation process. An application of this type was implemented in the catalogue itself to compute the equivalent macroseismic magnitude of all the earthquakes for which a minimum number of intensity rated localities is available.

For all these reasons, we believe the catalogue represents an important step towards the definition of common standards for collecting and analyzing historical seismicity data. Our next step will be to encourage all the scientists who may contribute to a better understanding of Italian historical seismicity to join this project, participate in the debate for setting appropriate common rules, and get ready to include

their information in future releases of the catalogue.

REFERENCES

- BELLANI, A., D. POSTPISCHL and M. STUCCHI (1989): Dal catalogo dei terremoti alla banca dati macrosismici, in *I Workshop of the «Gruppo Italiano Informatica Applicata alle Scienze della Terra»*, Sarnano, Italy.
- BERGAMASCHI, S., G. FERRARI, P. GASPERINI, D. POSTPISCHL and A. VOLTA (1981): Sistema informativo per la gestione e la elaborazione automatica dei dati sismici nazionali, *Rend. Soc. Geol. It.*, **4**, 685-692.
- BOSCHI, E., G. FERRARI and E. GUIDOBONI (1992): PERSEUS project: A GIS (Geographic Informative System) for historical seismic data, organization and first results, in *XXIII General Assembly of the European Seismological Commission*, Praha, September 1992 (abstract).
- BOSCHI, E., G. FERRARI, P. GASPERINI, E. GUIDOBONI, G. SMRIGLIO and G. VALENSISE (1995): *Catalogo dei forti terremoti in Italia dal 461 a.C. al 1980*, ING-SGA, Bologna, pp. 973, with CD-ROM.
- FERRARI, G., P. GASPERINI and E. GUIDOBONI (1995): Macroseismic intensity evaluation with the «Fuzzy Sets Logic», *Annali di Geofisica*, **38**, 811-826 (this volume).
- GUIDOBONI, E. (Editor) (1989): *I terremoti prima del Mille in Italia e nell'area Mediterranea. Storia archeologia sismologia* (SGA, Bologna), pp. 765.
- GUIDOBONI, E., A. COMASTRI and G. TRAINA (1994): *Catalogue of Ancient Earthquakes in the Mediterranean Area up to the 10th Century*, published by ING, Bologna, pp. 504.
- GUTENBERG, B. and C. RICHTER (1956): Earthquake magnitude, intensity, energy and acceleration, *Bull. Seismol. Soc. Am.*, **46**, 105-145.
- HANKS, T.C., and H. KANAMORI (1979): A moment magnitude scale, *J. Geophys. Res.*, **84**, 2348-2350.
- POSTPISCHL, D. (Editor) (1985): Catalogo dei terremoti italiani dall'anno 1000 al 1980, *Quad. Ric. Sci.*, PFG-CNR, **114 (2B)**.
- POSTPISCHL, D., M. STUCCHI and A. BELLANI (1991): Some ideas for a databank of macroseismic data, *Tectonophysics*, **193**, 215-223.
- SCHWARTZ, D.P. and K.J. COPPERSMITH (1984). Fault behavior and characteristic earthquakes: examples from the Wasatch and San Andreas fault zones, *J. Geophys. Res.*, **89**, 5681-5698.
- STUCCHI, M. (1990): Verso una razionalizzazione della base di dati macrosismici, in *Atti del Convegno GNDT 1990*, 1-23.