Historical Earthquakes in Central Europe		Volume I	Editors: Rudolf Gutdeutsch, Gottfried Grünthal, Roger Musson	
Abh. Geol. B.-A.	ISSN 0378-0864 ISBN 3-900312-83-4	Band **48**	S. 33–50	Wien, August 1992

Historical Earthquake Research – an Example of Interdisciplinary Cooperation between Geophysicists and Historians

By UTE EISINGER, RUDOLF GUTDEUTSCH & CHRISTA HAMMERL[1])

With 9 Figures an 1 Coloured Plate (in pocket)

Contents

Zusammenfassung ... 33
Abstract ... 34
1. Why we Study Historical Earthquakes ... 35
2. Aims and Methods of Historical Earthquake Research ... 37
3. Methods of Historical Earthquake Research ... 38
3.1. Examples of the Text Material about the Earthquake of December 4, 1690 in Carinthia ... 39
3.2. The Development of a Measure of Equivalent Values of Messages and its Importance to Seismic Risk Analysis ... 42
4. Artistic and Photographic Depictions in Historical Earthquake Research ... 43
4.1. Historical Development of Scientific-Technical Depictions ... 43
4.2. Texts and Scientific-Technical Depictions as Media of Messages about Historical Earthquakes ... 43
4.3. June 28th, 1763 – the Komárno earthquake ... 44
4.4. Photographs of the Earthquake of Kecskemét 1911, July 8th ... 46
5. An Italian Earthquake Catalogue as an Example ... 47
5.1. The Problem of Completeness and Accuracy – Historical Sources of Earthquakes in Italy since 1000 p.C.n. ... 47
5.2. The Mean Repetition Rate of Damaging Earthquakes in Italy ... 48
6. International Organizations ... 48
7. Conclusion ... 49
Acknowledgements ... 49
References ... 49

Historische Erdbebenforschung – Ein Beispiel interdisziplinärer Zusammenarbeit zwischen Geophysikern und Historikern

Zusammenfassung

Die seismische Risikoanalyse erlangt zunehmend durch den starken Bevölkerungszuwachs in vielen Ländern an Bedeutung, dies trifft besonders für Gebiete mit niedriger Seismizität zu und ist für Standorte technischer Großbauwerke wichtig. Geophysiker und Historiker arbeiten zusammen, um Antworten auf z.B. folgende Fragen zu finden:

1) Wie stark waren die historischen Erdbeben und was waren die regionalen spezifischen Mechanismen?
2) Wie hoch ist die Wiederholungsrate von Schadensbeben in bestimmten Regionen?
3) Ändern seismisch aktive Zonen im Laufe der Jahrhunderte ihre Lage?
4) Welche seismische Gefahr ergibt sich für einen Standort auf Grund der Erforschung historischer Erdbeben?
5) Welche neuen Einsichten in soziologische, ökonomische, politische, religiöse und kulturelle Verhältnisse der jeweiligen Zeit können durch die historische Erdbebenforschung gewonnen werden?

Die Grundlagen zur Erforschung historischer Erdbeben stammen aus der zeitgenössischen Dokumentation, den Quellen. Diese sind hauptsächlich Texte, aber auch Gemälde und Fotografien können wichtig sein. In wenigen Fällen findet man hilfreiche Relikte, wie Erdrutsche, zerstörte oder rekonstruierte Gebäude.

Die originale Quelle wird im Laufe der Jahrhunderte durch die wiederholte Berichterstattung desselben Ereignisses verändert. Die eigentliche Arbeit beginnt daher mit dem Zurückverfolgen jüngerer Texte bis zur zeitgenössischen originalen Quelle. Texte müssen zuerst entziffert, historische geographische Namen interpretiert und alte Datierungen und Maßstäbe in heutige umgewandelt werden (Entfernungen, Dauer des Erdbebens, Währungen, um Rechnungen für die Reparatur von Gebäudeschäden richtig einschätzen zu können).

[1]) Mag. UTE EISINGER, Univ.-Prof. Dr. RUDOLF GUTDEUTSCH, CHRISTA HAMMERL, Institute of Meteorology and Geophysics, University of Vienna, Währingerstraße 17, A-1090 Vienna.

Einer der schwierigsten Teile der Arbeit ist die Quellenkritik. Textbeispiele des 1690er Kärntner Erdbebens geben einen Eindruck, wie die Dokumentation eines historischen Erdbebens im Verlauf von Jahrhunderten eine zumindest formale Deformation erfährt. Der Wert einer Quelle hängt auch davon ab, ob die Frage aus seismologischer oder aus historischer Sicht gestellt wird.

Für die seismologische Interpretation ist eine Wertung der Quellen nach Kriterien wie: 1. Verläßlichkeit, 2. Genauigkeit und 3. Vollständigkeit notwendig. Die Karte des Schüttergebietes des Erdbebens vom 15. September 1590 in Niederösterreich (Epizentrum Neulengbach) ist ein Beispiel von Quellenklassifikation. Stellt man eine Isoseistenkarte ohne Rücksicht auf die Qualität der Quellen her, unterscheidet sie sich wesentlich von der, die nur verläßliche Quellen heranzieht. Die Ergebnisse sollen durch einen „Gleichwertigkeitsmaßstab" vergleichbar gemacht werden.

Die Bedeutung von Bildern wie Gemälden und Zeichnungen als Interpretationshilfe historischer Erdbebenschäden wird anhand zweier Beispiele veranschaulicht. Es existieren drei zeitgenössische Bilder von Komárno, einer Stadt im Grenzbereich ČSFR und Ungarn, die am 28. Juni 1763 durch ein Erdbeben zerstört wurde. Die Bilder zeigen dieselben Gebäude von derselben Perspektive aus und erlauben somit einen direkten Vergleich. Es ist bemerkenswert , daß zwischen den Bildern auffallende Unterschiede bestehen. Zum Teil kann dies durch die subjektive Sicht des Malers und seines Auftraggebers erklärt werden. Das zweite Beispiel bezieht sich auf das ungarische Erdbeben vom 8. Juli 1911. Eine Fotografie eines zerstörten Hauses wird gezeigt. Der dazugehörige Text beschreibt einen größeren Schaden, als auf dem Bild zu sehen ist.

Ein italienischer Erdbebenkatalog zeigt deutlich, daß mit der Zeit die Daten der Ereignisse allmählich genauer und vollständiger wurden. Die Grafik „Anzahl berichteter Erdbeben / Zeit" kann als eine Art „Kulturbarometer" bezeichnet werden, das den Zeitbegriff der jeweiligen Epoche und das Interesse an naturwissenschaftlichen Fragen zeigt. Dieses Beispiel zeigt auch, daß die mittlere Wiederholungsrate von Katastrophenbeben nur für eine Zeitspanne von 200 Jahren repräsentativ ist.

Die Europäische Gemeinschaft unterstützt ein internationales Projekt „Review of Historical Earthquakes", das Erdbeben in einem Zeitfenster von 100 Jahren – 17. und 18. Jahrhundert – untersucht. Die Europäische Seismologische Kommission befaßt sich durch die Arbeitsgruppe „Historical Earthquake Data" mit der historischen Erdbebenforschung. Ihr Ziel ist die Überarbeitung von Erdbebenkatalogen, die Ausarbeitung von Richtlinien und die Erstellung einer Monographie. Ihre Mitglieder sind Geophysiker und Historiker aus 15 europäischen Ländern.

Abstract

In view of the fast increase of population in many countries, the analysis of seismic hazard has become more and more important even for regions with low seismicity. This is essential especially for the estimation of the risk of sites for large technical structures. Geophysicists and historians cooperate to find answers to questions such as follows:

1) How strong were the historical earthquakes and which are their regionally specific mechanisms?
2) What is the recurrence rate of damaging earthquakes in certain regions?
3) Do seismically active zones vary in position in the course of centuries?
4) What seismic hazard follows from the investigation of historical earthquakes for a site?
5) Which new insights into sociological, economic, political, religious and cultural circumstances of the time can be gained from historical earthquake research?

The basis of our knowledge about historical earthquakes comes from the contemporary documentation, the sources. They mainly consist in texts, but painted or photographic depictions can be of importance as well. In rare cases relicts such as landslides, destruction or reconstruction of buildings, which are still visible today can serve as a helpful tool. The original message of contemporary documents undergoes a deformation during the centuries by writers who refer to the event. Thus the work starts with the search for contemporary material by tracing back later texts to the sources. Once the texts have been deciphered, one has to interpret historical geographical names and to transfer ancient dates and measures (distances, duration of the event, monetary units of invoices paid for the repair of damaged buildings) to today's systems.

The most difficult part of the work is the source critique. Examples of texts of the 1690 Carinthia earthquake give an impression how the documentation of historical earthquake news underwent at least formal changes. The value of a source depends on whether the question comes from the seismological or from the historical point of view.

For the seismological interpretation it is necessary to evaluate the sources after criteria such as: 1. reliability, 2. precision, 3. completeness. The map of the "felt area" of the Lower Austrian earthquake of September 15th, 1590 (epicenter Neulengbach) serves the sources as an example of classification. If one draws the isoseismal map using all sources regardless of their quality, the shape of isolines differs greatly from that which has been drawn using only reliable sources. The results have to be supplemented by a "scale of equivalent values" in order to make them comparable.

The importance of depictions such as paintings and drawings as a help for the interpretation of effects of historical earthquakes is shown by two examples. Three contemporary depictions of the town of Komárno damaged by the earthquake of June 28th, 1763 are existing. These depictions show the same buildings from the same perspective and therefore allow a direct comparison. We find it remarkable, that the presentations exhibit striking differences. They can partly be explained by the subjective viewpoint of the painter towards the earthquake and the opinion of his patron. The second example comes from the Hungarian earthquake of 1911, July 8th. The photography of a damaged house is presented. The respective text suggests a greater damage than can be seen in the depiction.

An Italian earthquake catalogue clearly shows that on the average the data of the events gradually have become more precise and complete. The graph of the numbers of reported earthquakes per time can be interpreted as a kind of "cultural barograph" which in its deviations shows the development of the conception of time and the interest in questions of the natural sciences. The example also shows that estimates of the mean repetition rate of catastrophic earthquakes are representative for a period no longer than 200 years. The European Community supports an international project "Review of Historical Earthquakes" investigating earthquakes which occured in a 100 years time-window during the 17th and 18th century. The European Seismological Commission in its working group "Historical Earthquake Data" deals with questions of historical earthquake research such as the revision of earthquake catalogues, the elaboration of recommendations and the compilation of a monograph. Its members are geophysicists and historians from 15 European nations.

1. Why we Study Historical Earthquakes

Great earthquakes can cause catastrophic disasters when occurring in densely populated areas. Highly developed technology constitutes a sensitive factor which sometimes multiplies the seismic risk by the factor of thousand or more. Earthquakes do not belong to that kind of natural phenomena which occur periodically as the inundation of rivers by melted snow, which regularly threatens the lowlands during spring. This threat is met efficiently by preventive measures such as dikes. Earthquakes do not announce themselves as hurricanes do before passing over cities. They happen incidentally and to a high degree obey laws of statistics. Only when having observed enough events during a given span of time, can conclusions about the total collective of data be drawn by means of statistics. That is why occurrence time, location and magnitude of great earthquakes cannot be predicted precisely by presently known methods.

In Central Europe great earthquakes are rare and their statistical mass is small. It may happen, that the design of a planned structure needs data of a much higher precision than can be gained from the empirical seismological knowledge about the site: The risk is the product of probability and the expected losses. Therefore, even when the probability of earthquake occurrence is low, the increasing construction activity of technical structures in a densely populated region forms a threat to the environment (such as nuclear and water power plants and waste deposits). Therefore the demand for a more reliable earthquake hazard estimation increases as well. This demand could probably be satisfied, if we extend the observation time of seismicity to earlier centuries.

These circumstances make understandable why historical earthquakes become subject of political debates from time to time. Two examples are referred to: In 1978 Austria in a plebiscite decided against the running of the nuclear power plant at Zwentendorf. About 400 years before, September 15th 1590, a great earthquake occurred near Zwentendorf with its epicenter 30 km south of it. This earthquake, besides other arguments, contributed considerably to the later political decision of Austria against the construction of nuclear power plants. In 1989 Hungary stopped the construction of the water power plant at Nagymaros, on the Danube river, which was a part of a cooperation project of Hungary and ČSFR. One of the decisive arguments of this decision came from the fact that in 1763, June 28th, at the town of Komarno, not far from Nagymaros, a destructive earthquake happened. The stopping of this project turned out to be costly to the Hungarian government because many companies involved in this project sued for damages.

The growing environmental consciousness of the public, particularly for the construction of nuclear power plants, brings to light how important a better knowledge about historical earthquakes is. This can be shown clearly by the reflection as follows:

Water is needed for different reasons for generation of electric energy. Therefore, naturally, water power plants are sited on rivers. The demand of cooling water leads the designers of nuclear power plants to select sites next to rivers as well. But, unfortunately, many rivers follow tectonic fault systems with enhanced earthquake hazard.

The situation is illustrated in Fig. 1. It includes both, the epicenters of damaging earthquakes (Δ) since 1000 A.D. redrawn from LEYDECKER's catalogue (1986) and the sites of nuclear power plants (●) in 1987 on the basis of the IAEA publications (1986). The most important earthquakes are indicated with the year of occurrence. Their maximum intensity has been added in brackets.

Earthquakes predominantly occur in the lower Rhine valley area, the Upper Rhine valley, the Swabian Alp and the Alps[2]). The North German plain and the Netherlands have a very low seismicity. The area of the Upper Rhine valley forms a typical geological graben structure with subsidence effects and post-volcanism phenomena. Its tectonic activity continues since Tertiary times and before. The strongest earthquake in this region since immemorial times occurred in 1356 with the epicenter about 30 km SW of Basel. It damaged the town of Basel severely and destroyed many villages and castles. As the strongest earthquake north of the Alps this event plays an important role in the seismic hazard assessment of this and the neighbouring regions. LEYDECKER's catalogue associates this event with the maximum intensity of X at the epicenter, whereas MAYER-ROSA & WECHSLER (1991) give an estimation of only IX. AHORNER, MURAWSKY & SCHNEIDER (1970) in an earlier publication estimated the value of VIII for the maximum intensity of this shock reached in the territory of the FRG. These differing and partly contradicting estimations of intensities are based on historical reports only. They make understandable why historical earthquake research aims at a better estimation of intensity distribution and the maximum intensity particularily of this big shock, where the sites of several nuclear power plants are not too far from the supposed epicenter.

The lower Rhine valley contains another seismic active zone striking from Cologne WSW via Belgium to England. The most ancient nuclear power plant in the FRG in this area, Jülich, was built in 1961–1969. This time falls into a period before the emergence of a sense of environment responsibility and before the development of respective concepts. The same seems to be true for the nuclear power plant at Großraum in the former GDR near Rheinsberg (construction started 1960, began running 1966).

---

[2]) The basic literature of these earthquake zones can be found in:
ILLIES, J.H., BAUMGARTNER, H. & HOFFERS, B.: Stress Pattern in the Alpine Foreland. – In: Tectonophysics, **71**, p. 157–172, (1981).
MAYER-ROSA, D. & WECHSLER, E.: Das Erdbeben von Basel 1356. Schäden und seismologische Beurteilung. – In: Historical Earthquakes in Central Europe = ESC-Monograph (in preparation).
AHORNER, L., MURAWSKI, H. & SCHNEIDER, G.: Die Verbreitung von schadensverursachenden Erdbeben auf dem Gebiet der Bundesrepublik Deutschland. – Zeitschrift für Geophysik, **36**, p. 313–343, 1970.
AHORNER, L.: Historical Seismicity and Present-Day Microearthquake Activity of the Rhenish Massif, Central Europe. – In: K. FUCHS et al. (ed.): Plateau Uplift, p. 198–221, Berlin – Heidelberg – Wien 1983.

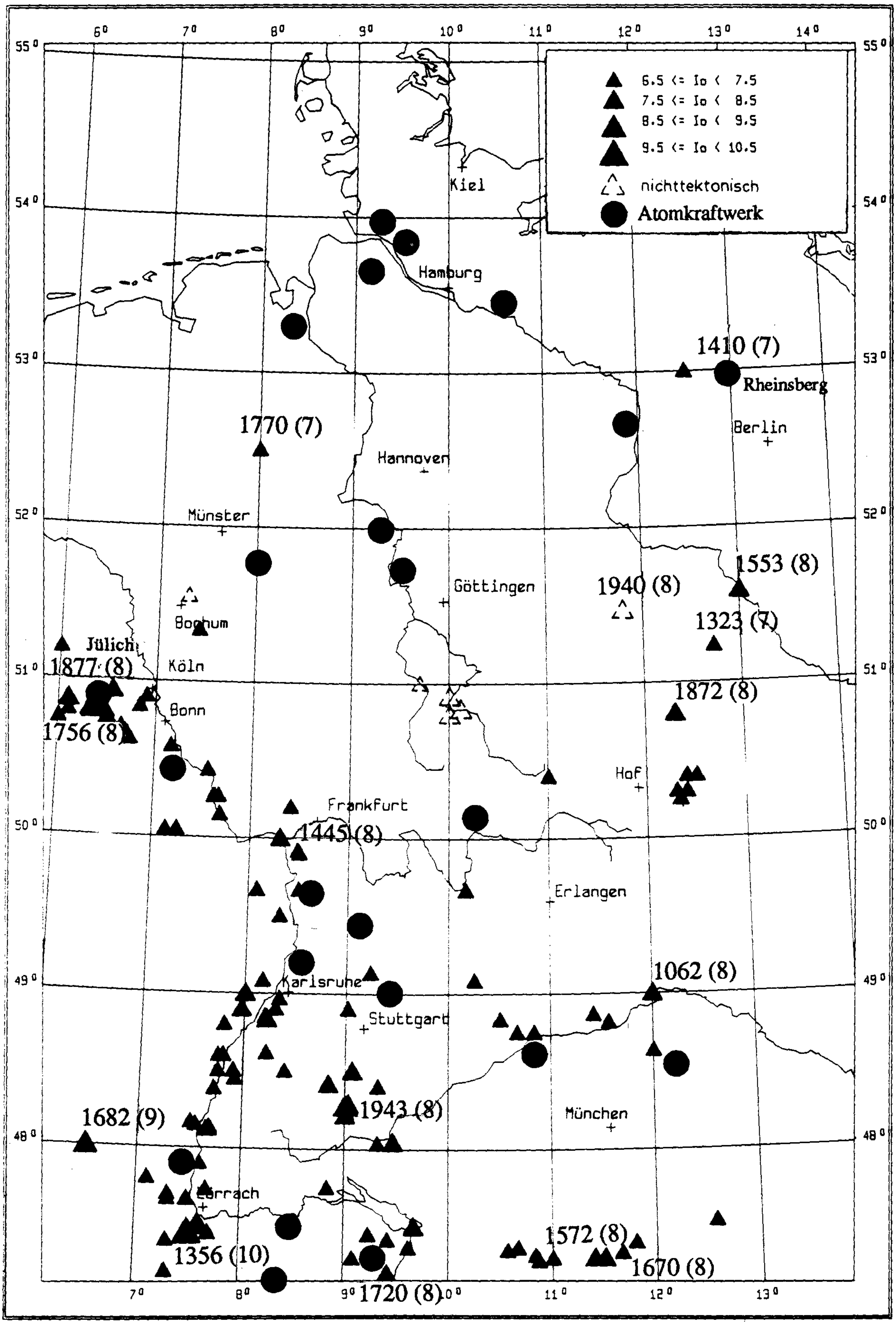


Figure 1.
This figure shows that nuclear power plants have been mainly established on rivers and thus in zones of enhanced seismic risk.
Δ = Epicenters of damaging earthquakes in Central Europe 1000–1981, redrawn after LEYDECKER (1986); ● = Atomic Power Plants (State 1987).

2. Aims and Methods of Historical Earthquake Research

Instrumental observations of earthquakes go back to the end of the last century. Earlier reports come mainly from written documentation about visible, audible and perceptible (i.e. macroseismic) effects of earthquakes. Interesting phenomena such as alterations of the earth's relief, the appearance or disappearance of springs, formation of cracks, settings and building damage are also recorded. Based on observations of this kind the seismic intensity scale has been developed. Nowadays European seismologists use the intensity scale of MEDVEDEV, SPONHEUER and KARNIK (1981), the MSK-scale. Objections have been raised against the general application of this scale to building damage caused by earthquakes in historical times. Therefore, for every document of the seismic event, it has to be tested first whether it justifies an intensity determination or more information is necessary. One important argument can be, whether or not the damaged historical building still exists. Another argument comes from environment studies. The earthquake hazard depends sensitively on the local groundwater level. It could be that since the historical earthquake the groundwater level has changed. This could possibly happen as a consequence of regulation of rivers, which happened mostly during the 19th century, and the construction of water reservoirs in the 20th century. One example has been given by GUTDEUTSCH, HAMMERL, MEYER & VOCELKA (1987). If an estimate of the intensity and the drawing of isoseismal maps is possible, then seismological parameters such as RICHTER's magnitude or the mean ground acceleration can be estimated by well-known empirical relations.

Historical earthquakes can therefore contribute to the aggregate of seismic data for an area, and the hazard. An example has been given in Fig. 2, where lines of the probable maximum intensity have been plotted for the region of the FRG.

The unbiassed contemplator of Fig. 1 and Fig. 2 could be misled to the conclusion, that the epicenters of great historical earthquakes are the centers of maximum seismic hazard of the future. Furthermore, he

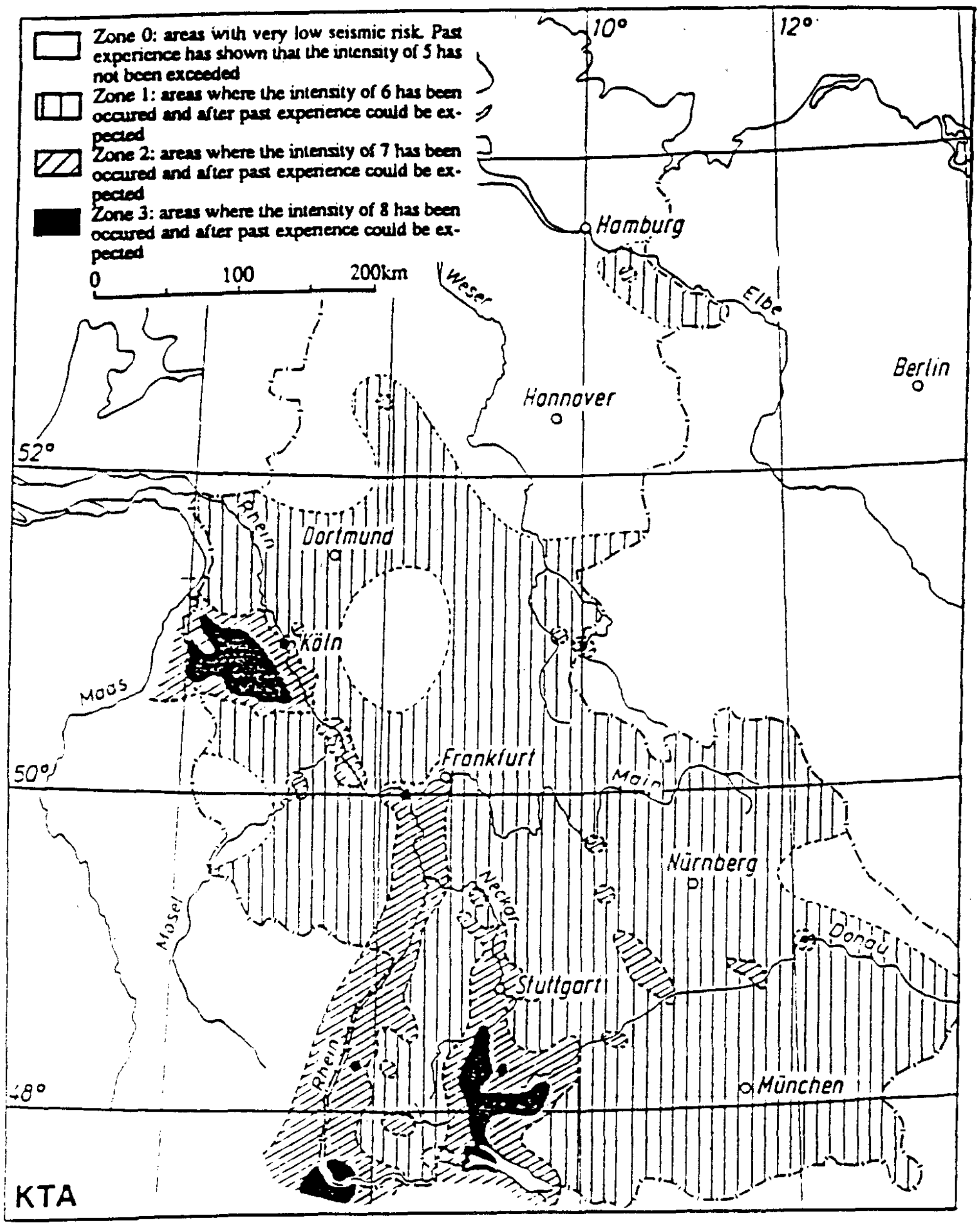


Figure 2.
Zones of probable maximal intensities in the FRG, based on earthquake data from the last 1000 years.
The number of big earthquakes is too small for a statistical covered conclusion about the seismic hazard. The high intensity values in SW-Germany come from the only big earthquake happened 1356 next to Basel. Today this map is regarded as a first information only. In every case of risk assessment a thorough study of seismic and tectonic situation of the site is needed.

would assume, that with increasing distance from these old epicenters the seismic risk decreases. This conclusion seems obvious and contributes to the official rule of the FRG for the construction of nuclear power plants (KTA-rule 2201)[3]).

Yet, this figure veils, that earthquake occurrences obey statistical laws in time and locality. GRIMMEL & KOCH (1982) have noticed this and other shortcomings of the KTA-rule. It is true that after a great shock numerous aftershocks happen in the same epicentral area – even after years. But only in very rare cases it happens that another catastrophic earthquake occurs later, exactly in the historical epicenter. It seems much more realistic to expect future earthquakes in the geological neighbourhood of the epicenter. The term "geological neighbourhood" describes a spatial extension of the geographic area, in which future earthquakes can be expected. It describes a critical distance, which could possibly be taken from geological data, i.e. about active fault systems. In areas with weak seismicity as the N part of the FRG the information density about active faults and seismic events is very small. Respectively the statistical mass is small and does not admit conclusions of the demanded precision. The maps of maximum intensities and maximum accelerations suffer from this drawback. One typical example can be seen by the comparison of Figs. 1 with 2: Fig. 1 shows a historical epicenter at 12°E and 49°N near the town of Regensburg. This single shock led the interpreter to draw a narrow local anomaly of the isolines of maximum intensity as shown in Fig. 2. From this anomaly the fallacious concept of a locally high earthquake risk could be suggested. Besides, recent investigations of P. WOLF & H. WOLF (1989) make the reality of this historical earthquake questionable. If these doubts will be confirmed, the map shown in Fig. 2 has to be corrected and one can take for sure that the anomaly near Regensburg will disappear. This example demonstrates that maps like this one are helpful tools, but their importance is limited. The user should know the basis on which they rely.

Objections against Fig. 2 and other disadvantages led authorities to adjust the KTA rule to a newer version of 5/90. This newer version recommends to use Fig. 2 as a first and general information only.

Besides, the study of historical earthquakes is interesting not only for seismologists. The close link to historical sciences opens some more aspects. The documents may provide important references to the contemporary public attitude to natural disasters such as earthquakes. A. BORST (1985), for instance, uses the earthquake disaster of Villach/Austria in 1348 in order to present and interprete the reaction of the contemporaries under the stress situation of a natural catastrophe. Here historical research of an earthquake served as a tool for a peculiar purpose. Another study published by W. NEUMANN (1987, 1988) consists in a careful source critiques about contemporary and non-contemporary texts about the same earthquake. Seismological information was not the objective of these authors.

3. Methods of Historical Earthquake Research

Historical earthquake research consists of a seismological and a historical component. The first one has an aim, which is precisely defined but only can approximately be achieved: to know exactly what actually happened during an earthquake and hence the numerical parameters of the earthquake. The long-term objective consists of statistically derived hazard maps as mentioned above. We find the assessment of error limits of focal parameters very important though in most cases they cannot be given.

Yet, an earthquake also has social consequences. The investigation of these aspects comprises the second component of Historical Earthquake Research. The dismay about the sudden and terrifying event motivates various human activities. Public and private help to earthquake victims, sermons, private letters, books, newspapers and leaflets, give us a glimpse into the religious, philosophical, political and economic situation of the period.

Thus, methods and aims of historical earthquake research have many different aspects. As a matter of fact the information capacity – or what we call the "value" of a particular contemporary source about an earthquake – depends on the special question. Fig. 3 shows a flow chart of the method. A text, once found, has to be deciphered and translated. This important work demands professional training. The contemporary terms have to be transferred to seismological terms originated in the 20th century. This part of the study sometimes turns out to be a fascinating work. It may happen that terms describing earthquake phenomena such as destruction or sound effects appear uncommon to us. The fact that the verbal expression changes with time makes a translation to the 20th century terms necessary. Established historical methods help e.g. to redate the time given by the contemporary author, should he have used a different calendar[4]). Many historical earthquakes are mentioned in short notes years or centuries later in different writings. Most of them do not include any analysis or deeper scientific study. Therefore, the next step consists of tracing back the information of the given references to their sources[5]). In many cases this detective task takes the main part of the total work. For many historical earthquakes, mainly from the middle ages and earlier, all or many contemporary sources got lost or cannot be found. Thus these events can only be reconstructed partially. The stemma, i.e. a geneological tree of texts, helps to understand how younger writings depend on elder ones. It clears up copying errors of older texts and shows how the original message is deformed as it passes the

---

3) KTA-security rule, interpretation of KKW against seismic influences, part 1: Principles, KTA 2201, version 6/75 ,14. The KTA-rule 2201, valid since 1975: *"Wenn sich Epizentrum oder Bereiche höchster Intensität von historischen Erdbeben in der gleichen tektonischen Einheit wie der Standort befinden, ist bei der Ermittlung der Beschleunigung am Standort anzunehmen, daß diese Erdbeben in der Nähe des Standortes eintreten."*

4) Basic information about the different calendars since the Middle Ages is given by GROTEFEND, H.: Taschenbuch der Zeitrechnung des deutschen Mittelalters und der Neuzeit. – Hannover 1982.

5) In this paper we use the terms sources or contemporary sources for documents only, which stem from contemporaries of the earthquake. Later publications are called literature, texts or writings.

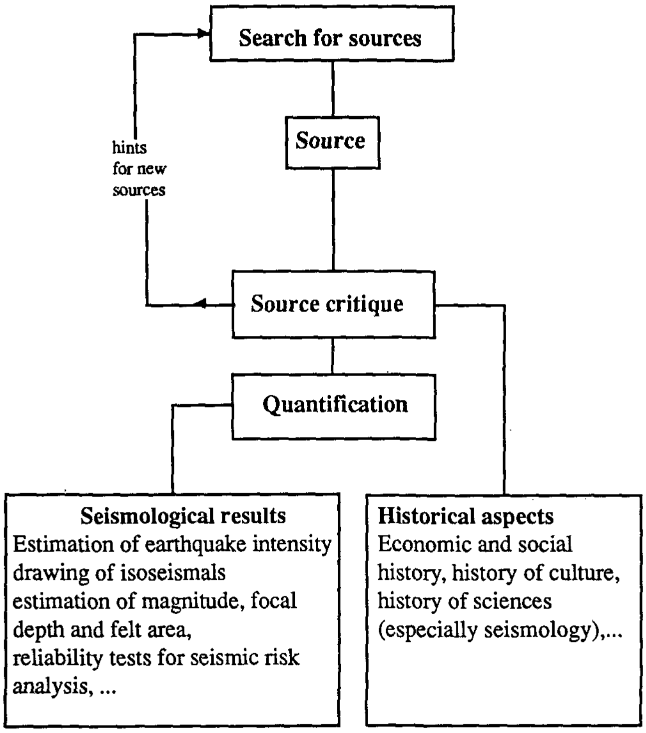


Figure 3.
Flow chart of methods of Historical Earthquake Research.

centuries. This analysis, the source critiques[6]), gives the basis for assessing the value of the message.

It should be stressed here, that historical earthquakes have motivated not only contemporary writers to write but also artists to paint or to draw. Important compilations about such paintings, woodcuts and drawings have been published by KOZÁK & THOMPSON (1991) and many others. Historical depictions of earthquakes open a fascinating field of interpretation which will be introduced in chapter 4 of this paper. In special cases contemporary historical depictions of earthquakes can be used as very important historical sources.

The procedure sketched in the flow chart (Fig. 3) has been applied sucessfully to the few big historical earthquakes in the territory of Austria in the 14th to 18th century. But Austria has a moderate seismicity only. Therefore the procedure cannot be regarded to be definite. More experience with historical earthquakes in different epochs and different countries could possibly make modifications, supplements or even alterations of this concept necessary. For instance, if one aims to compile a complete representation of all earthquakes having occurred within a given period, expecting hundreds or thousands of earthquakes, a systematical search through all the material available in archives and libraries for earthquake could be preferable. This strategy has been used by the investigators of the CEC project "Review of Historical Earthquakes" (see chapter 5).

[6]) See:
BRANDT, A. v.: Werkzeug des Historikers, p. 49ff, 1958.
KUSTERNIG, A.: Erzählende Quellen des Mittelalters. Die Problematik mittelalterlicher Historiographie am Beispiel der Schlacht bei Dürnkrut und Jedenspeigen 1278, Wien 1982.
LHOTSKY, A.: Quellenkunde mittelalterlicher Geschichte Österreichs. – In: Mitteilungen des Instituts für österreichische Geschichtsforschung, Ergänzungsband **19**, 1963.

As mentioned above, the message of seismological interest has a clear and limited importance. The original earthquake testimonies are set in order according to three aspects of their value:

1. Reliability.
2. Accuracy.
3. Completeness.

These criteria form the background when grading the historical source. They comprise the basis of the quantification. That means that the information is associated with a number and the error limits of this number. It is clear enough why reliability and accuracy are important criteria. Historical earthquake research should develop particular reliability and accuracy tests. The well known mathematical error calculation is only one of many possibilities. The tests should be sound and understandable for those, who are not familiar with terms of geophysical or historical sciences. In our opinion test methods as mentioned above have not been sufficiently considered in earlier publications. The designing engineer needs more than a "number" describing the seismic risk. As background information he also needs a knowledge of how this "number" was found. The term "completeness" requires additional explanations: A text written by an eye-witness of the earthquake generally is regarded as a very valuable information. Its descriptions of special features such as building damage can be very accurate. But if the time of occurrence is missing the message is not complete and it may happen that the earthquake cannot be identified. If several shocks occurred within a short time interval the message is completely worthless – despite of its high accuracy.

Contemporary texts may be exaggerated or deliberately misleading. It is important to understand the motivation of its author. Here the cooperation with local historians can be very helpful.

3.1. Examples of the Text Material about the Earthquake of December 4, 1690 in Carinthia

The transmission of earthquake reports through the centuries can be best illustrated by an example:

We have chosen the destructive earthquake which occurred in the area of Villach/Carinthia on December 4, 1690 (= December 24th, 1690 in the old calendar). This shock is of special importance for the risk analysis because it happened in a zone with a rather low seismicity in the 20th century. But very rarely unexpected big shocks occur, separated by long time spans of relative quietness. In the chosen example there exists a comparably good basis of literature and contemporary sources. 79 texts give an impression of the deformation process of the message during three centuries. The reason comes mainly from the alteration of interest in the Villach earthquake, even more in earthquakes in general, and the development and specialization of (print)media. Fig. 4 shows a graph of 79 texts about this earthquake chronologically set out according to ~~their number~~ and character.

The sources, i.e. reports of eye-witnesses, notes in chronicles, leaflets, letters etc., written immediately after the earthquake, are outstanding in quality and number.

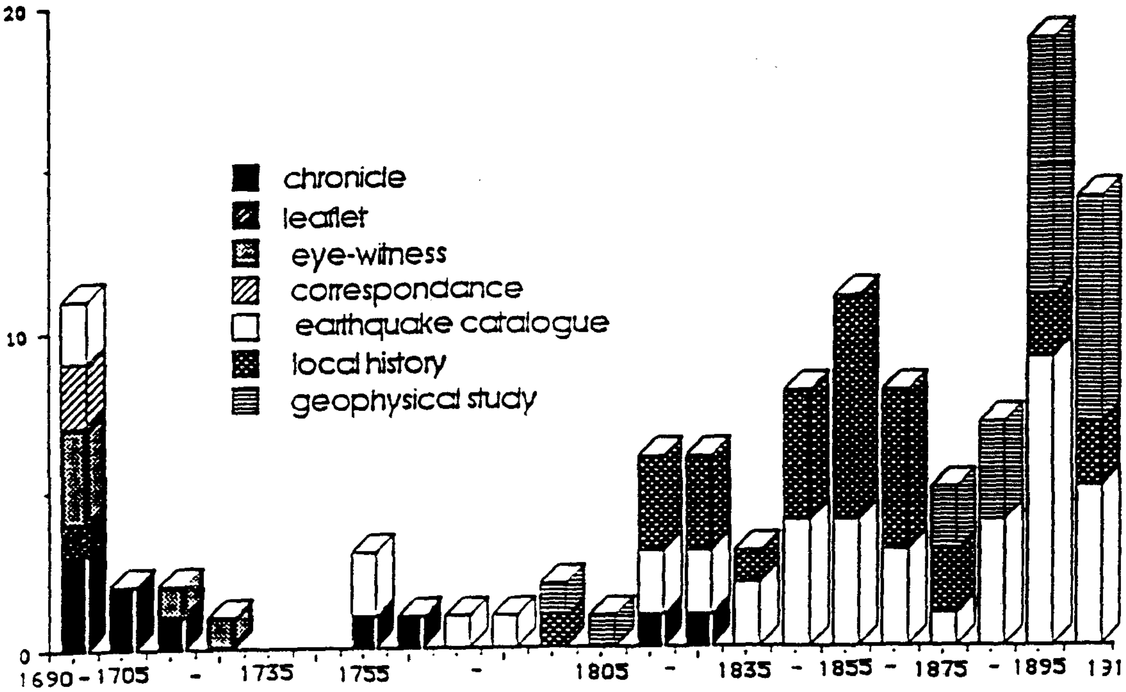


Figure 4.
Texts of different kinds on the Villach earthquake of 1690.

The most useful texts are diligent reports of eye-witnesses due to their high degree of reliability. In fortunate cases they may originate from a scientist as does the following report to the Leopoldian Academy, written by SCHELHAMMER (1690), who was professor at the Jena University:

" ... scilicet hic Jenae non per universum oppidum aeque perceptum fuisse, terram moveri, sed variis in locis atque plateis, haud parum dissitis. Primum in inferiore urbis parte, trans forum, in parte vero huius superiore nulla domus titubavit. Altius deinde ascendente clivo, cui templum imminet & turris, de qua dixi, quammaxime. Dehinc ulterius & recta, & ad latus utrumque perceptum est, reliquae urbis partes fere intactae. Neque tamen aedes vicinae pariter omnes commotae sunt nec eadem in linea contigue adiacentes nec e regione sitae, sic in platea Jenensium dicta Ecclesiastis venerabilis domus ita iactata, ut ianuae excussis repagulis aperirentur e regione, vix octo passibus distans domicilium nihil passum est. Idem illic loci, ubi tum eram, amici conviva, observatum est, nos enim, in tertia licet contignatione aedium, nihil percepimus, domus e regione ad 6. passus distans contremuit. In domicilio quod nunc inhabito, nemo quicquam observavit, eum ad viginti passus ex altero plateae latere manifestus motus esset; Imo quod magis mirabile, in eadem contignatione ex una parte magnarum aedium existentes sensere, e regione, in altera degentes quieti, omniumque rerum ignari fuerunt ... ".

SCHELHAMMER explains in which parts of Jena the earthquake was felt and considers the phenomenon of the shock strength being different in different sites to be very remarkable.

The following example is not less accurate. Its cultured author LENTILIUS (1694), who was town physician of Nördlingen in those days, asked witnesses and studied some damages on an excursion before writing his article:

" ... Terra ipsa rubens & ochrea. Ubi primum abscessit a monte, ad sex pedes mons ipse subsedit, ad duius radicem via cava (ein Hohlweg) penitus obliterata fuit, latitudo a prima terrae a vulsione atque ad viam cavam erat passuum centum & septuaginta, longitudo autem ab introitu in viam cavam ad eius exitum, passuum centum atque vigint. Et comprimis est memoratu dignum, pomum arborem haud quidem adeo proceram ad viginti duorum pedum distantiam e loco natali vi terrae motus evulsam, super viam istam cavam, erectam transmigrasse, radices ibidem egisse, & iam ante annum uberrimos fructus largitram esse, quin eos & hoc anno multitudine oculorum praegnantissimam spondere. Sed & omnes isti hiatus, & arbusculae ipsius migratio a meridie septentrionem versus spectabant ... "

LENTILIUS describes in detail a landslide caused by the earthquake and the state of soil. He gives length and width (120 and 170 paces respectively) of the landslide and the displacement (6 feet).

Detailed numerical values like these – the author himself measured out the site – are rarely to be found. LENTILIUS's local inspection was a private venture: supported and accompanied by his noble patron, the scholar and physician examined the place.

When printing became cheaper and newspapers more popular, the old way of recording extraordinary events by chronicles degenerated into private diary writing or keeping the tradition, e.g. in monasteries or by provincial parsons.

See the following example taken from the (Latin) Diarium of the Ljubljana Jesuits:

" ... Notabene: Hodie quoque circa horam quartam fuit fortis potens terrae motus, qui varia damna tam in civitate, quam in collegio causavit, praesertim quod ex eo una turris nostra fuerit incurvata ... "

A strong earthquake caused various cases of damage in the town. In the Jesuit monastery one of the towers was bent.

This message is inaccurate according to time and damage given in it ("different damages"). On the other hand, the hint that one tower has been bent could be helpful, if historical architectural information is available. In which state was the building at that time? Was it dilapidated before? Had it been newly erected? etc. – questions like these are important for the intensity estimation of damaging earthquakes. Account book entries of the money spent on repair works describing the damage are a valuable find. Rebuilder's estimates can be "made up" for the purpose of tax exemption – This example shows, how much information depends on being supplemented by local history.

Most of the information offered by contemporaries of the 1690 earthquake can be found in "chronicles of disasters", a genre, which became popular after the Thirty Years War, when printing was cheap and the reading audience missed the news of the war papers. The following example will illustrate this kind of publication listing up catastrophes:

" ... Des historischen Kerns oder so genandten kurtzen Chronica dritter Theil, fürstellend: Die merckwürdigsten Welt= und Wunder=Geschichte / so sich in und ausser Europa in diesem noch währenden Land= und Leuth=verderblichen Krieg/so wohl zu Wasser als Lande von Anno 1690 biß 1695 zugetragen. Hamburg 1695, p.135f:
Das ungewöhnliche Erdbeben.
Den 24. NOV. in der Nacht ließ sich in Türingen und Meissen ein hartes Erdbeben vermercken/welches der Orthen ein gantz ungewöhnliches Entsetzen verursachte; Aus dem Fürstlichen Schlosse zu Weissenfels RETERIRten sich die hohen Fürstlichen Persohnen/in der Nacht in das Lust= und Garten=Hauß/weil dero Bette/Stühle und Tische übel zerstossen wurden/und man Augenblicklich sich eines jähen Ruins besorgen muste: Die Glocken schlugen von sich selbst an: In Torgau war das halbe Schloß eingefallen: In Leipzig und Naumburg haben die Thürme als eine Wiege hin und her gewancket; Deßgleichen auch in dem Cöllnischen/Gülischen und Bergischen. Nachgehendes hat man erfahren/daß dieses Erdbeben auch an unterschiedenen Orthen im Reiche in Bäyern/Oesterreich/Rom und Venedig /ja fast in gantz Europa verspühret worden/und an vielen Orthen grossen Schaden und Entsetzen verursachet. Zu Villach in Kärnten hat es mehrentheils alle Häuser und Kirchen zur Erden gestürtzet/und die Stadt zu einen Steinhauffen gemacht. In der Steyrmarck hat es gantze Oerther RUINIRET: In Schlesien und den 6 Städten hat es sich auch grausam erzeiget/daß die Thuerme gebebet/und die Glocken geklungen: Dem alten Prediger und PRIMARIO zu Görlitz/sind die Bücher davon aus dem REPOSITORIO gefallen/und hin und wieder die Zinnen/kupfferne und andere Gefässe von den Borten und Ricken herunter gefallen/daß es keine geringe Erschütterung müsse gewesen seyn ... "

The author tells us the "story" about high society escaping from their collapsing manor house. Then he gives a list of towns struck by the earthquake.

Here a contemporary collected material about disasters such as earthquakes, tornados, human monstrosities, naval battles and inundations. Any information about place, time and damages is beyond the compiler's interest, who produced his "Chronica", compiling the "most interesting events" of the past decade for sale to a sensation-seeking public. The topic that even noblemen cannot escape misfortune is still common in today's magazines. It sounds rather unlikely that in the town of Torgau, 500 km from the epicenter, – "half the castle broke down": The text offers only vague indications where to continue the research.

Fig. 4 shows how the number of contemporary records about the earthquake decreased in the course of time after the event.

After the disastrous earthquake of Lisboa (1756) the interest in earthquake increased again. This is indicated by numerous "earthquake catalogues", i.e. (sometimes of local relevance) calendars of old notices collected in archives and from chronicles by scientists, journalists or historians. According to its intention the quality of the "earthquake catalogue" varies between the frivolous sensational story and the ambition to detect geological rules by a chronology of earthquake data.

See an example from:

Chronica oder Sammlung alter und neuer Nachrichten von den merkwürdigsten Erdbeben, sowohl wie solche seit der Schöpfung bis zu gegenwärtigen Zeiten in allen vier Theilen der Welt geäussert, als auch, was selbige für Ursachen zum Grunde haben; dem Publico getreulich mitgetheilet von M.J.A.W. Wien 1764, p53ff:

"... Dieses Erdbeben äusserte sich auch zu obgedachter Zeit und Stunde sowohl in Venedig und den umliegenden Landschaften und Insulen, woselbst nur einige Schornsteine abgeworfen, als auch in sehr vielen Städten Deutschlandes, nämlich in Frankfurt am Mayne (allwo der Eschenheimer= und Catharinen= wie auch Pfarrthurm und hohe Häuser, sonderlich der Römer oder das Rathhaus, wiewohl ohne Schaden, erschüttert, und stark beweget wurden) in Hanau, Ulm, Augspurg, Regenspurg, Heydelberg, Straßburg, Nürnberg, Culmbach, Bayreut, Weimar, Jena (dessen oben ñ 80. gedacht worden) Buttstädt, Naumburg, Weissenfels, Pegau, Borna, Düben, Wittenberg, Lauben, Liebenthal, Dresden, und an mehr andern Orten in Hessen, wie auch in der Schweiz, ja fast in ganz Deutschland; ... "

M.J.A.W., an industrious collector of earthquake notes, listed towns shaken by the earthquake.

In this late state of retrospective view to the 1690 earthquake – one century later – many errors occur. – The event can be reconstructed from written reports only. Mistake place identifications, misinterpretations of calendars and time, translation errors, distorted summaries and exaggerations were published by interested scientists of different countries. The special earthquake texts appear more and more in combined and compiled form together with different topics, and distributions – Historical Earthquake Research has to find out the value of these texts and their seismological importance. In any case a message passing many centuries partly loses its concrete and precise meaning: The example above includes some vague information about the intensity by the sentence: " ... chimneys ... have been thrown down ... " Yet, the text: " ... countries and islands ... around Venice ... " does not say precisely enough where the chimneys have fallen down.

Fig. 4 shows the revival of interest in earthquakes during the 19th century, the century of science. This is true especially in its second half, which in the German speaking countries was determined by nationalism and Positivism, the interest in local history as much as well as natural science (publications).

See an example listing up earthquakes of the year 1690 out of:

BOEGNER, J.: Das Erdbeben und seine Erscheinungen. Nebst einer chronologischen Übersicht der Erderschütterungen im mittleren Deutschland vom 8. Jahrhundert bis auf die neueste Zeit und eines Zusammenhanges mit vulkanischen Erscheinungen in entfernten Ländern. Frankfurt/Main 1847, p106:
1690, den 24. November, hat man durch die ganze Stadt Frankfurt a. M. zu Abends zwischen 3 und 4 Uhr ein Erdbeben verspürt.
1690, den 4. oder 5. Dezember, Erderschütterung auf einem großen Striche Deutschlands. Sie wird empfunden in Villach, Klagenfurt, Wien, Bopfingen, Hohentrudingen, Nördlingen, Straßburg, Heidelberg, Frankfurt, Baireuth, sogar zu Jena, Altenburg, Dresden und Meißen. Die Stöße erfolgten zwischen 3 und 7 Uhr. ... Auch von Köln wurde die Erschütterung berichtet ... "

BOEGNER writes that the earth shook in Frankfurt on Nov. 24th and in Germany and Austria on December 4th or 5th, 1690, too.

The author used several sources dated after the old Julian calendar and others dated after the new system (between 1582 and 1700 the Gregorian calendar replaced the old one). He drew the wrong conclusion that two different earthquakes occurred in winter 1690, slipping in a misinterpretation of calendar systems. Later authors copied this error of two earthquakes – in one case even a third one: 14. XII. 1690 because of a wrong correction of the calendar mistake.

At the end of the 19th century Seismology starts as an independent discipline. This can be seen clearly in Fig. 4 showing the beginning of a new publishing activity by a steep ascend of the curve.

The examples given have shown how earthquake information comes to us influenced by perspectives and intentions changing in the course of centuries. Some kinds of texts proved to be more useful for our information requirements than others.

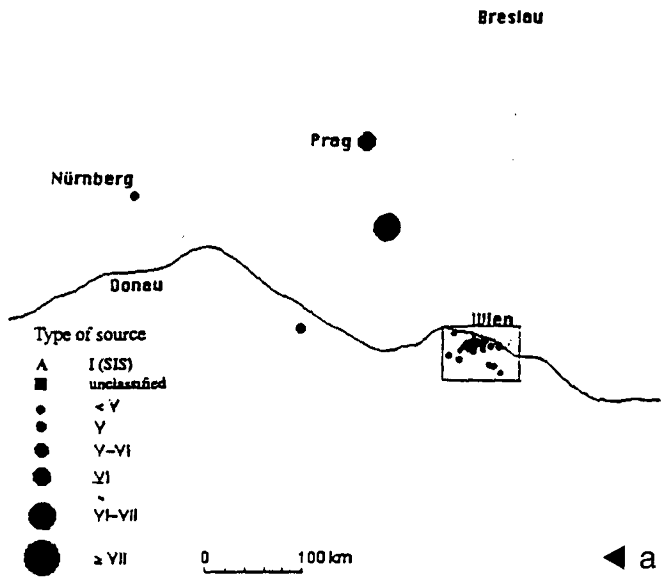
Reports of eye-witnesses often are very valuable, such as SCHELHAMMER's. Sometimes contemporary texts written by authors who collected and examined reports by asking witnesses are just as valuable as reports describing the damage (local inspection). LENTILIUS is a good example.

The investigation of earthquakes of other centuries would have revealed a completely different source situation. For example the appearance of scientific magazines during the 19th century introduced a new element for spreading earthquake information. Most of the contemporary literature is not very useful for seismological analysis, but reflects the contemporary view of – and attitude to – natural phenomena. See the "Unglücks-Chronica" mentioned above.

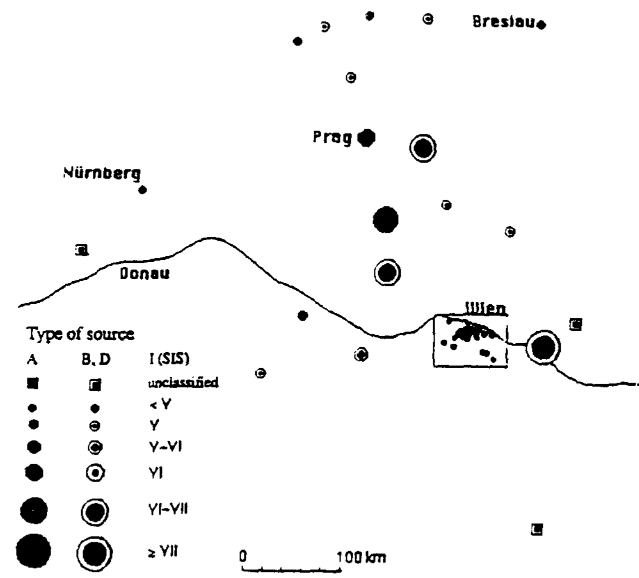
3.2. The Development of a Measure of Equivalent Values of Messages and its Importance to Seismic Risk Analysis

A recent study of the earthquake of September 15th, 1590[7]) presents a classification the literature covering this event into five categories A to E. These five categories designate the structure of the historical messages and consequently are associated with different seismological importance. With certain restrictions one can say, that A has the highest and E the lowest value.

Type A: Contemporary description (reports of eye-witnesses, invoices of paid sums to repair damaged buildings, etc.).
Type B: Annals, chronicles, historical compilations.
Type C: Mainly natural scientific contemplations about earthquakes.
Type D: Texts with a tendency (e.g. religious or economic: sermons, pamphlets).
Type E: Mainly earthquake catalogues (which often refer to sources which cannot be traced back to their origin).



◄ a



▲ b

c ▼

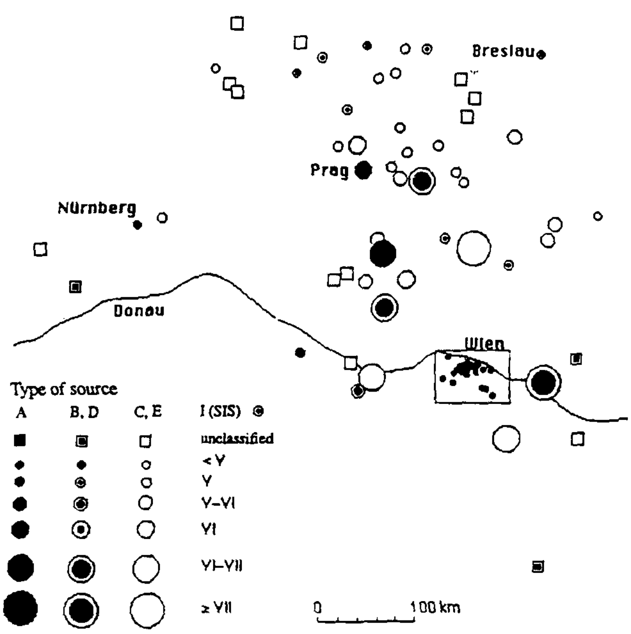


Figure 5. →
Spatial distribution of reports of the earthquake Sept. 15.–16. , 1590.
a) Reports of type A and intensities of the earthquake 1590, September 15th; the observation does not justify the drawing of isoseismals. The messages from the epicentral area – dots in the rectangle – messages from the epicentral area – don't represent the intensity but only the geographical location. The drawn points are mainly sources, that means texts of type A with the intensity VIII° and VIII°–IX°.
b) Reports of the types A, B and C of the earthquake 1590, September 15th; note that mainly the area north and northeast of the epicentral area is covered with additional information.
c) All available reports (classes A, B, C, D and E) of the earthquake of 1590, September 15th.
In contrast to Figs. 5a and 5b many additional reports come from greater distances of the earthquake (200-400km). Many of them are so inaccurate and partly incomplete, that they do not allow an estimate of intensity.
The comparison of Figs. 5a, b and c indicates a decrease of the seismological value of earthquake messages with increasing distance to the epicenter.

[7]) GUTDEUTSCH, R., MAYER, I., HAMMERL, Ch. & VOCELKA, K.: Erdbeben als historisches Ereignis – Die Rekonstruktion des niederösterreichischen Erdbebens von 1590. – Berlin – Heidelberg – Wien 1987.

In a later study the consequence of this classification for the seismic risk analysis has been discussed by comparing Figs. 5a,b,c (Ch. HAMMERL, 1987). These figures make clear that the estimations of intensities in the far field are not as reliable as those in the near field, e.g. their statistical importances differ. The example visualizes, how the selection of messages according to their value influences the difficult decision as to where the VIII°, VII° and VI° isoseismals should be drawn.

If one selects the most reliable sources only (contemporary writers, type A) – Fig. 5a – it seems impossible to draw isoseismals, perhaps with the exception of the VIII° isoseismal. Including additionally texts of type B and D, one gets the impression that the felt area extends to NW, which is more clearly than in Fig. 5c, where all types of texts are taken into account. This special assymetry of the felt area is confirmed by the observation of many East Alpine earthquakes of the 19th and 20th century. J. DRIMMEL, G. GANGL, R. GUTDEUTSCH, M. KOENIG & E. TRAPP (1973) used a model seismic experiment to explain it by an asymmetry of the wave guide below the Eastern Alps.

If one adds texts of type C and type E one gets a slightly different local distribution of messages. This fact could easily alter the decision how to draw isoseismals and could have consequences for the risk analysis of a site.

This example visualizes the problem of the selection of messages about locations which contribute to the isoseismal map. There are good reasons to take the most reliable sources only, i.e. reports of eye-witnesses, contemporary documents, invoices, reports etc. as a basis of isoseismal maps. In this case the literature (here: type C and E) would serve as a general information and a help tracing back the original sources, here it would not contribute to the isoseismal map and it would be impossible to draw the limits of the felt area and the isoseismals I<VIII° MSK.

These figures underline the demand for development of an equally defined "measure of equivalence for messages". This necessity holds for both, isoseismal maps and earthquake catalogues, only messages of the same type should be taken. If one uses different kinds of texts – as for instance annals and pamphlets – the question of its relative importance rises. The comparison represents one step toward the aimed test methods mentioned above: What we need is a procedure well suited to replace mathematical error computation commonly used in natural sciences but applicable to historical data.

4. Artistic and Photographic Depictions in Historical Earthquake Research

Artistical and photographic depictions of earthquakes communicate a seismological message as well. Surely they cannot be read like a written document and have their own language which has to be decoded before interpreting the message. Nowadays paintings exclusively belong to the field of fine arts. That is why the 20th century geophysicist usually would not expect a message of seismological importance from them. But we claim – and will confirm by basic arguments and examples later on – that contemporary depictions form a significant class of historical documents worth beeing given the same credit as written texts.

4.1. Historical Development of Scientific-Technical Depictions

First, paintings, drawings and woodcuts over centuries have been carried out for different purposes not only as fine arts but also as technical tools with the aim to present a physical process or visible thing. Depictions of earthquakes – similar to written reports – of "pre-scientific" time never reach the standard of "true representation" of 20th century earthquake pictures. The seismological message is concealed in a special "clothing" or "disguise". Contemporary painters had different motives and backgrounds to make an earthquake the object of their interest. In general they did not find it necessary to describe natural phenomena as accurately, completely, reliably and objectively as possible, which is a matter of course for 20th century seismologists. This attitude toward nature, fundamental to modern natural sciences, slowly arose in the 17th century. In the 18th century the great earthquake of Lisboa in 1755 stimulated many artists to depict and draw, what actually happened during the event. Drawings of high accuracy of building damages have been handed down as mentioned by KOZÁK et al. (1991). The interest in exact description and depiction of nature reached a broader public not earlier than 1800, when A. v. HUMBOLDT started to publish the discoveries from his voyages by texts, drawings and paintings. In this time painting and drawing were not only expression forms of fine arts but also powerful tools in the hands of engineers, architects and natural scientists. Both written texts about and depictions of historical earthquakes should be seen in this general development. This situation changed with the invention of the photography in the middle of the 19th century. Since then the depiction was replaced gradually by photography and finally disappeared completely from the scene of descriptive earthquake literature. Today it rarely happens that an artist tries to draw or to paint damage caused by an earthquake with the only aim to do this work as accurately and as completely as possible. Everyone knows that photography can do it much better. In this light the photography overtook the task of the "scientific-technical depiction". From now on we will use the term "scientific-technical depiction" in order to note the difference to the "depictions of fine arts". It will be shown below that source critiques reveals whether a historical painting about an earthquake can be associated to scientific-technical depictions, to the fine arts, to both or neither of them.

4.2. Texts and Scientific-Technical Depictions as Media of Messages about Historical Earthquakes

The second reason concerns the special kind of information transfer by pictures or words. Pictures and words communicate messages – we should rather say "mental images" – fundamentally different in their content and view of the same matter or object as N. POST-

MAN (1980) pointed out by many examples. His context is interesting for our topics insofar as it includes a fundamental discussion of the photography as a medium, which we may extend to scientific-technical depictions of earthquakes.

" ... The photography also lacks a syntax, which deprives it of a capacity to argue with the world. As an "objective" slice of space-time, the photograph testifies that someone was there or something happened. Its testimony is powerful but it offers no opinions – no "should have beens" or "might have beens". Photography is pre-eminently a world of fact, not of dispute about facts or of conclusions to be drawn from them ... "

In our case this disadvantage turns out as advantage. The painter's conclusions, opinions and statements about the historical earthquake are not of interest for us, because we want to know what actually has happened. To know them would merely help to check the reliability of the depiction as a historical source. From this point of view the scientific-technical depiction – not the written word – appears as the adequate transfer medium in historical earthquake research – according to the wellknown proverb "one picture tells more than 1000 words". This conclusion seems sound but it is not completely correct. Why? The basis of our interpretation is the MSK-intensity scale which consists in written texts describing earthquake effects, building damages, reactions of people and so on. The inventors of the scale selected terms and comparisons, which shall evoke the correct mental image to the interpreter of what actually happened during the earthquake. Furthermore they associated descriptive sentences such as "most of the chimneys drop down" with numbers, in this case:

"most" is equivalent to ">60%"

As a matter of fact, the carefulness in finding the best fitting terms for the scale and their link to an adequate number appears to us a distinguished scientific pioneer's task. Yet here a special problem arises when using documents of historical earthquakes: The terms used for describing earthquake effects vary in historical times and therefore we cannot be sure that historical texts have to interpreted 1 : 1 in relation to modern texts. Here an example: A German historical source about damages caused by the earthquake 1590 in Lower Austria says:

"Das Rueberischer Schloß ist heute zuhauf gefallen ... ",

which approximately means in English:

"The castle of Rueber there today has been overthrown and fallen to ground ... " (see R. GUTDEUTSCH et al., 1987).

Does this message mean partial or total collapse of the building? Interpretation problems of this kind cannot arise when using depictions of a historical earthquake – but other ones emerge instead! This will be shown below.

We conclude that the "language of images" offers an adequate tool to characterize the effects of historical earthquake damages and therefore completes the information of written texts. The scale could effectively be improved by a collection of pictures presenting earthquake effects and damages of different kinds and grades.

We would like to visualize the importance of depictions for historical earthquake research by two examples as follows:

4.3. June 28th, 1763 – the Komárno Earthquake

In 1763, June 28th, a destructive earthquake happened next to the town of Komárno/Danube. The event occurred in a time of highly developed governmental organisation, which characterized the cultural prosperity during the reign of emperor Maria Theresia. Many sources have been handed down, which make an approximate determination of the extension of the meizoseismic zone and the epicenter at 18.3°E, 47.6°N possible (BROUCEK, 1978). It belongs to a wellknown seismic zone as can be seen in Fig. 1 of GRÜNTHAL's study in this issue. The Hungarian earthquake catalogue associates this shock with the maximum intensity of IX° degrees MSK (T. ZSIROS, P. MÓNUS & L. TÓTH, 1988), while V. KARNÍK & G. SZEIDOWITZ (1990) suppose VIII-IX° only. This discrepancy led to the political controversy about the water power plant in Nagymaros as mentioned in chapter 2. The question arises whether scientific-technical depictions of earthquake damage to buildings in Komárno, which recently have been found, can help to clear up this question. In the following text we refer to the paper of I. BROUCEK, U. EISINGER, V. FARKAS, R. GUTDEUTSCH, Ch. HAMMERL & G. SZEIDOWITZ (1990). In Komárno the Jesuit's church and college suffered great damage from the shaking. Both towers of the church fell down and killed several people. This damage has been described in the contemporary reports by the Komárno Council[8]) as follows:

" ... 1763 junius 28 Komárom vártosa
Civitas Comaromiensis Consilio Locumtenentiali Regio ad intimatum die 11 julii statum urbis exponit ... Die 8–a Augusti 1763
... Patrum Societatis Iesu, futurae parochiaalis, magnis sumptibus constructa iamiam consecrata, decus et ornamentum civitatis nostrae, magna in parte cum duabus turribus decidit, muris et tecto non illease stantibus ... "

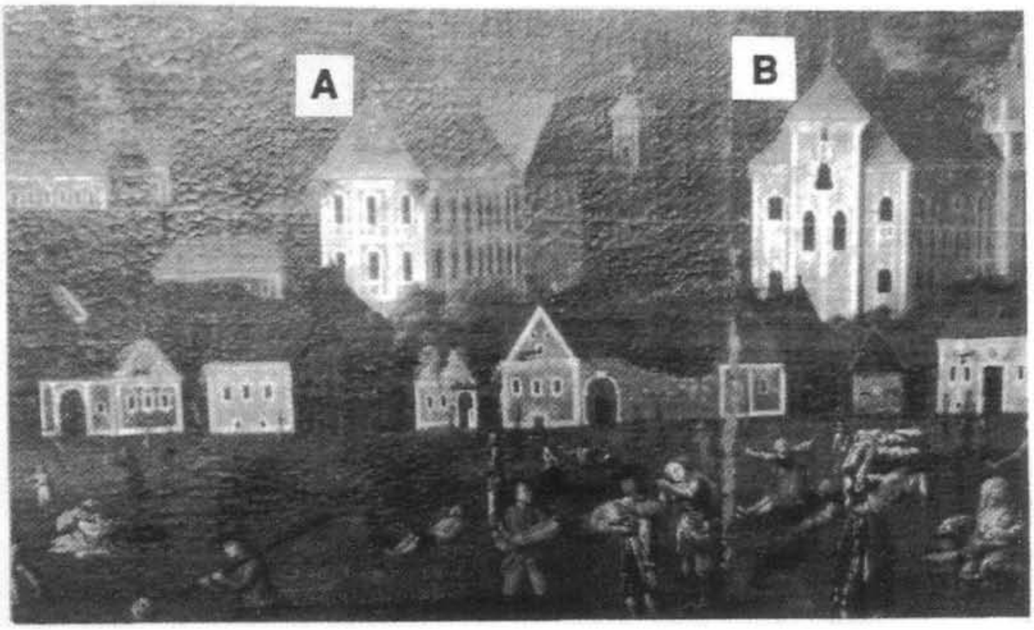
with the translation:

" ... The Jesuit church, the future parish church, constructed at high costs, short time before consecration, 'ornamentum and decoration' of our town, collapsed with the two towers nearly completely; walls and roof are standing but damaged ... "

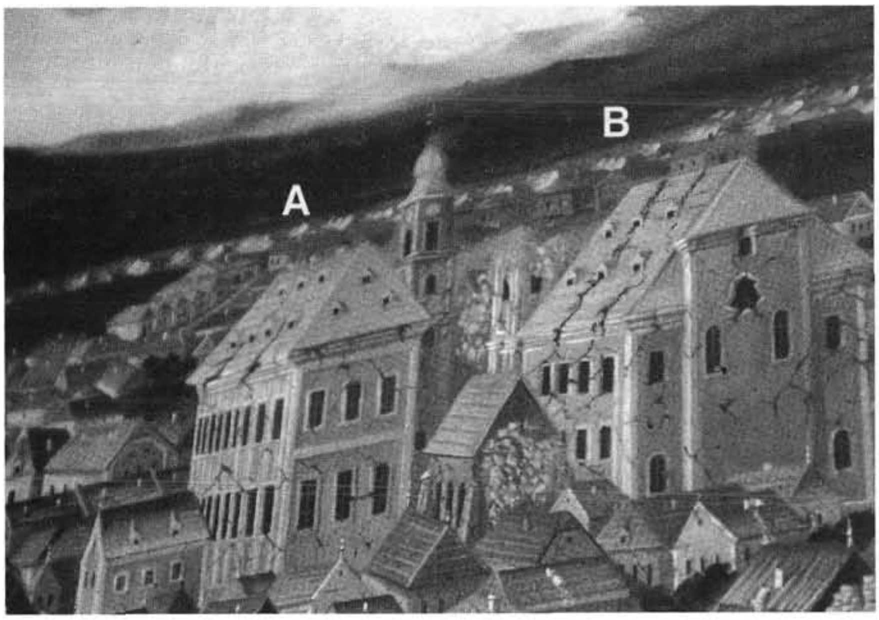
This short report states the damage, but does not describe details of what actually happened and which was the kind of damage. Did the towers brake at the level of the tower clocks? Did the roof of the tower or the complete tower including the walls collapse? Here the scientific-technical depictions of the damage can help. Two paintings and one drawing have been handed down representing the damaged town of Komárno weeks or months after the earthquake. Among many other buildings they show the Jesuit church and the college too. Enlarged partial views of these depictions are shown in Figs. 6a, 6b and 6c:

Figure 6a is the enlargement of a painting in oil on linen, probably ordered by the council of Komárno. The painter is Karl Friedel, the present owner the Múzeum of Komárno/ČSFR. The restoration brought to light that the painting is actually an over-painting of an older one, which can be dated to 1720 (43 years before the earthquake) or earlier. Obviously the painter undertook a tricky task. Some of the damaged buildings of 1763 did not yet exist in the older painting. This actually is true for the Jesuit church itself (see M. MÁCZA, 1985).

[8]) National Archives Budapest, Orsz. Levélt. Arch. Regnicol. Ladd. CCC. Fasc. A, Num 46.



◀ a



◀ b

Figure 6.
Depictions of the Komárno earthquake.
a) Enlargement of Friedel's painting of Komárno.
b) Enlargement of the votiv painting of Komárno.
c) Enlargement of Kastner's drawing of Komárno.
A: Jesuit college; B: Jesuit Church.
Plate 1 (in pocket) shows Fig. 6a and b in color.

▼ c

Historical Depictions of the Komárno Earthquake

(Explanations see p. 44–48)

Fig. 6a from p. 45.

Fig. 6b from p. 45.

Vice versa, such buildings still standing in 1720 and therefore painted in the earlier depiction, but pulled down before the earthquake, could have caused interpretational problems to the painter. From the artist's point of view the painting was carried out with great skill. The damage to buildings has been properly depicted as typical earthquake effects. The figure shows that the right tower has broken down on the half length. The relicts of the left tower were concealed by the main building. Breaks between roof constructions and side walls are represented. Tiles and parts of masonry are shown as falling down to the left (in this case to the west). Some gable fronts of houses have partly collapsed.

Figure 6b is the partial view of a votive painting in oil on linen, painted in 1766, restored in 1854. The artist's name is unknown. The present owner is the monastery of the Franciscan friars in Frauenkirchen/Burgenland, Austria. This depiction shows details of building damage more stylized, so that the impression arises, that the painter either saw the town of Komárno months after the event, when all damage on houses has been repaired or he was never there. Probably many details of damage got lost in the course of restoration 90 years after the event. Cracks in the walls have been painted in black. As a matter of fact, fresh cracks should look grey or red because of the uncovered bricks below the plaster. But they can darken with the time. It seems possible that the artist has enhanced the cracks in order to make them more impressive. The comparison between Figs. 6a and 6b shows many differences of the same building and the same damage. Which is the more realistic one?

The third contemporary depiction of Komárno, a water coloured sketch with map and extensive legend, probably was done shortly after the event by Joseph Kastner, engineer of count Theodor Batthiany. A partial view of this drawing is given in Fig. 6c. The author's target was to demonstrate the damage caused by the earthquake. For him the geographic localization of damaged houses (map) was as important as the presentation of the destruction itself. The destruction has been drawn in a rather general way. This comparison led BROUCEK et al. to the opinion that the damage reached grade 4 of the MSK-scale. It should be emphasized that this conclusion could not be drawn solely from the written texts.

4.4. Photographs of the Earthquake of Kecskemét 1911, July 8th

This earthquake has been studied by D. CSOMOR (1978) and others. He found the epicenter at 46.9° N and 19.7°E in Hungary not too far from the town of Komárno. From this shock many photographs of damaged buildings have been handed down. We select one particular example in order to demonstrate the importance of the differences of "mental images" communicated by depictions or by texts. Fig. 7 has been taken from CHOLNOKY's publication (1912). This photograph shows the damage to a building in the Gyík street of Kecskemét/Hungary. The upper part of the roof front has collapsed, but the main part of the building and the chimney still stands. The text below says " ... rombadölt ház", which means "collapsed house". We have to observe, that in that time the intensity scale of MSK was not generally introduced yet. The author calls "collapsed" what we rather would call "partially collapsed". The text without the depiction would lead to a wrong estimation of the grade of damage according the MSK-scale. Here the depiction controls the conclusion from the text.

48. ábra. Rombadölt ház (csizmadia műhely) a Gyík-utcában Kecskeméten.

Figure 7.
Damage to a building caused by the Kecskemét earthquake in 1911.
The texts below says "collapsed house in the Gyík street".
The photograph brings to light that this statement is exaggerated.

5. An Italian Earthquake Catalogue as an Example

5.1. The Problem of Completeness and Accuracy – Historical Sources of Earthquakes in Italy since 1000 p.C.n.

The importance of measures such as completeness and accuracy can be shown by the documentation of the Italian seismicity. Italy has a comparably long written tradition. The catalogue, compiled by POSTPISCHL et al. comprises about 20000 earthquakes which occurred since 1000 P.D. In other words, the time span covers nearly 1000 years. We accomplish another graph as shown in Fig. 8, taken from the data of the catalogue. It presents the total number of earthquakes occurring in a time interval of 50 years (upper curve) and the respective number of earthquakes, where the month, the day, the hour, the minute or the second of focal time has been published (Fig. 8, lower curves). In the half-logarithmic presentation the ordinate value of 0 arbitrarily has been replaced by 5.

a) Completeness

The steady and rapid increase of the number of recorded earthquakes cannot be related to an increase of the tectonic activity in Italy since 1000 P.D. but probably mostly follows from the increase of written documentation. In this scope the graph forms a "cultural barograph". It reflects the ups and downs – but over a longer period the general increase – of the technical capacity for writing or printing facilities. Probably a complex relation to the public interest in natural observations exists as well. The figure makes clear, that not earlier than 1900 can the data be regarded as being approximately complete, as the upper curve seems to reach a horizontal asymptote. This is a consequence of the installation of the Italian network of observatories with seismographs in the end of the last century. Many earthquakes of the catalogue have been published without their magnitude. But, regarding the catalogue since 1900, we can conclude that it is not complete down to the Richter magnitude m_b = 3.

b) Accuracy

In the Italian earthquake catalogue years, months, days, hours, minutes and seconds of focal times have been listed, where this data has been available to the authors. The standard of this specific information has increased since 1000 P.D. and is linked to the accuracy in the sense mentioned above. Figure 8 shows a plot of the number of messages on focal times. One can say that the accuracy of timing gradually increases through the centuries. The curves lead to some interesting conclusions. The sources of the catalogue coming from the Renaissance or earlier times provide the date information mainly from clerical calendars, which later gradually came out of use. The data of hours have been given in the scale of the "canonical time scale", which varies with season. They have to be transferred to our time scale. Minutes are published rarely. Yet, in some cases they can be derived indirectly (see for example the review article of FERRARI & MARMO, 1985). The curve of the minute-accuracy practically starts at the end of the 16th century, after Henlein's invention of the "Nürnberg egg-clock" found a wider distribution on European market after 1575. This clock is regarded as the precursor of the watch. In the second half of the 19th century Italy began the general installation of seismographic observatories with pendulum chronometers. Their time accuracy was in the order of some tenths of a second. Nowadays in seismological observatories the time is controlled by quartz clocks, triggered by radio transmitters. The accuracy of these timers is much higher than that of pendulum clocks.

Fig. 8 not only shows the general increase of the contemporary "timer" accuracy, but it also reflects development and variations of the human concept of time from 1000 P.D. to the present.

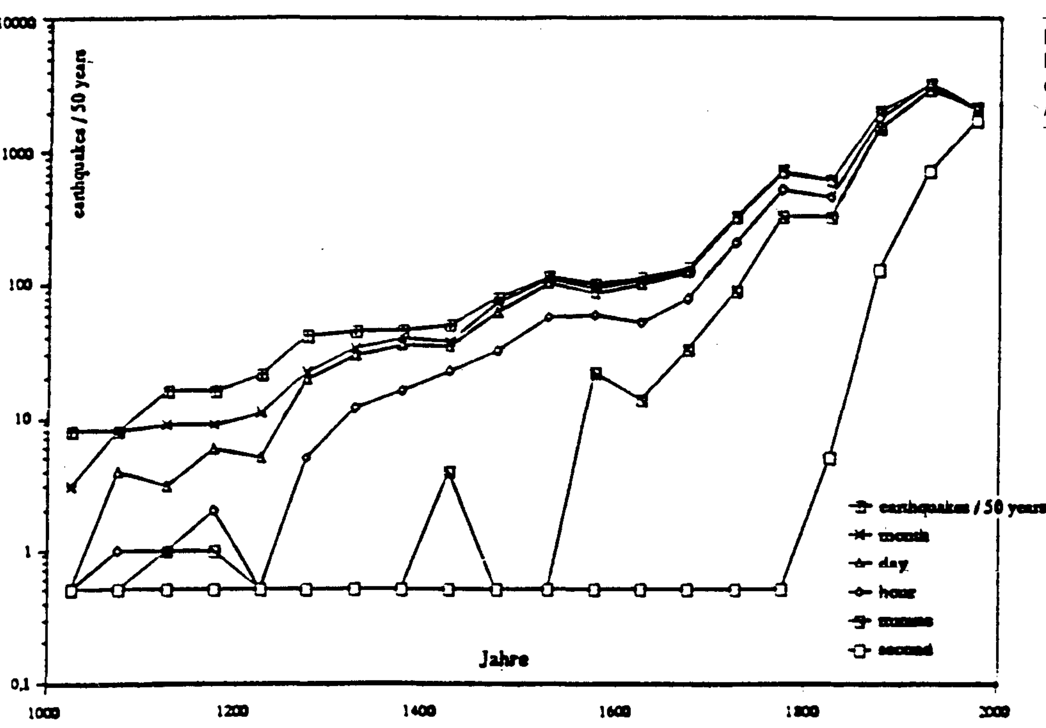


Figure 8.
Number n of recorded earthquakes per 50 years in Italy.
After POSTPISCHIL et al. (1985)

5.2. The Mean Repetition Rate of Damaging Earthquakes in Italy

Fig. 8 cannot provide the necessary basis for statistical prediction of earthquake catastrophes in Italy, as the collection of data is incomplete. It seems reasonable to expect that the contemporary writer has focussed his attention mainly on the catastrophic earthquakes with spectacular destruction and many people killed. Smaller shocks without building damage could easily escape from his attention and therefore could remain unmentioned. Thus the statistic collection of greater earthquakes would be nearly complete, whereas that of smaller shocks more incomplete. One can test the completeness by gradually excluding earthquakes below a given maximum intensity level from the statistical mass. In Fig. 9 three curves have been plotted. They present the numbers of earthquakes recorded during 50 years with maximum intensities of $I_0 >= $ VIII° MSK (upper curve), $I_0 >= $ IX° MSK (medium curve) and $I_0 >= $ X° (lower curve) (In the half-logarithmic vertical scale the value 0 has been replaced by 0.5)[9]).

The 3 curves ascend gradually with time. This ascent forms the most striking feature of the upper curve with $I_0 >= $ VIII° MSK, where the curve for $I_0 >= $ IX° MSK starts with some ups and downs, which may be related to the number of events, which is too small for a statistical conclusion. Nevertheless one gets the impression that a general increase exists. This increase ends about in 1700 P.D. We can conclude with some restrictions, that the data mass of earthquakes of this selection since 1700 P.D. is complete. This result seems important for both the geophysical and the practical point of view. It can be taken as a successful test, that the tectonic stress release by great earthquakes in Italy has remained constant for the last 200 years. Consequently a conservative estimate of the future earthquake risk can be given. The mean repetition times T of catastrophic earthquakes in Italy are

T = 3 years for $I_0 >= $ IX degrees MSK (observation time 200 years)
T = 11 years for $I_0 >= $ X degrees MSK (observation time 200 years).

Here the observation time is much greater than the repetition time of great earthquakes. Therefore the result is statistically significant.

Conclusions of this importance can be drawn for countries with high seismicity only. Of course we would need a much longer observation time in countries with lower seismicity. This is especially true for Central Europe where the repetition time of very big earthquakes is longer than – or as long as – the time of written documentation – about thousand years. This fact forms the basic problem of earthquake risk assessments in Central Europe.

6. International Organizations

The increasing importance of Historical Earthquake Research reflects the activity of international organizations related to different aspects of the earthquake risk analysis. The European Community has established a project "Review of Historical Seismicity". This project deals with the European seismicity in a time window from the second half of the 17th to the first half of the 18th century. The IAEA (International Atomic Energy Agency) and the IUGG (International Union of Geodesy and Geophysics) work out recommendations for historical earthquake investigations. The ESC (European Seismological Commission), a commission of the IUGG, comprises a working group "Historical Earthquake Research" with seismologists and historians of 15 European countries. This working group has tasks as follows

1) Revision of European earthquake catalogues.
2) Elaboration of guidelines and recommendations for historical earthquake investigations.

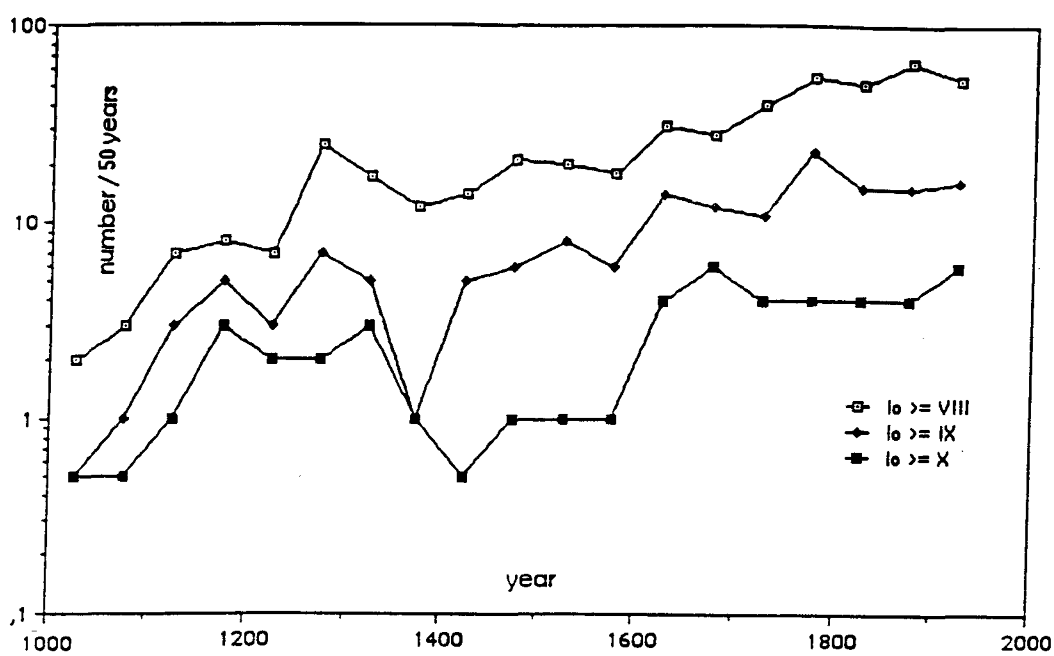


Figure 9.
Number of earthquakes per 50 years in Italy.
After POSTPISCHIL et. al. (1985).
1 = maximum intensity ≥ VIII°;
2 = maximum intensity ≥ IX°;
3 = maximum intensity ≥ X°.

9) This graphics is usually done with magnitudes instead of maximum intensities. We prefer maximum intensities I_0 here because they are given in the catalogue.

3) Publication of monographs, case histories of historical earthquakes and proceedings related to scientific conferences.
4) Organization of symposia and meetings on historical earthquakes in the frame of the ESC.
5) Collection and distribution of important data of historical earthquake research to users in the Eastern and Western hemisphere.
6) Establishment of a data bank of historical earthquakes.

7. Conclusion

The increasing importance of environmental questions led to an increasing demand of seismic hazard assessment taking historical earthquakes into account. This interdisciplinary research of seismologists and historians provides information about maximum intensity, magnitude, isoseismal maps and possibly focal parameters of historical earthquakes. It helps finding direct or indirect criteria of reliability as useful tools for seismic hazard assessments. This can be reached by the source critique of the material in view to the seismological message of the sources. The historian may find unexpected insights about the social and economic background of contemporaries of the event.

The contemporary sources and later literature and writings about the great Austrian earthquake 1690 next to Villach is presented in order to visualize the deformation of the seismological message during the centuries. The texts have been motivated by temporary actuality, sensation and the variable public interest in observation of nature.

One practical result of source critique is presented by the analysis of the great earthquake 1590 in Lower Austria. It shows how the historical "processing" of the data makes the subsequent seismological interpretation possible. A deliberate selection of the sources of one sort – for example annals or eye witness reports – used for drawing the isoseismals takes great influence on the shape of isoseismals and therefore can easily touch the statement of the seismic hazard assessment of a site. Therefore, it could be an important step forward to find a "measure of equivalence" of historical messages about earthquakes which should be defined uniquely. This measure would make sources and the subsequent results comparable, f.i. the statements in seismic catalogues.

Contemporary depictions as paintings, drawings, woodcuts as well as early photographs of earthquake effects form another important source of information. They transmit a mental image completey different from that handed down by written texts and provide a great additional help for the investigator. Two examples are presented which show the importance of depictions for the seismic interpretation and simultaneously makes clear the limits of the seismic interpretation.

The revision of consisting earthquake catalogues is another important task for historical earthquake research. The Italian earthquake catalogue 1000–1980 is used to show, that timing and completeness of data increased with time. The distribution of the number of earthquakes per 50 years plotted against time can be regarded as a "cultural barograph" rather than as an increase of seismic activity with time.

Acknowledgements

This paper presents first results of the research project P6868 "Historische Seismizität in Mitteleuropa" financially supported by the Austrian Science Foundation. This help is greatly appreciated.

References

AHORNER, L.: Historical Seismicity and Present-Day Microearthquake Activity of the Rhenish Massif, Central Europe. – In: E. FUCHS et al. (ed.): Plateau Uplift. – p. 198–221, Berlin – Heidelberg – Wien 1983.

AHORNER, L., MURAWSKI, H. & SCHNEIDER, G.: Die Verbreitung von schadensverursachenden Erdbeben auf dem Gebiet der Bundesrepublik Deutschland. – Zeitschrift für Geophysik, **36** (1970), p. 313–343.

BORST, A.: Das Erdbeben von 1348. Ein historischer Beitrag zur Katastrophenforschung. – Historische Zeitschrift, **233**/3, 529–569, 1981.

BRANDT, A. v.: Werkzeug des Historikers. – p. 49ff, 1958.

BROUCEK, I.: In: Atlas of Isoseismal Maps, Central and Eastern Europe. – KAPG, Geophysical Institute of the Czechoslovak Academy of Sciences, map in page 2, Prague 1978.

BROUCEK, I., EISINGER, U., FARKAS, V., GUTDEUTSCH, R., HAMMERL, Ch. & SZEIDOWITZ, G.: Reconstruction of building damage caused by the 1763 earthquake in Komárno/Danube from contemporary depictions of the same site and from respective texts. – Proceedings of the ESC-General assembly Barcelona, September 1990

CHOLNOKY, J.: A kecskeméti földrengés. – Földrajzi Közlemények XXXIX, p. 373–391, 1912.

Des historischen Kerns oder so genandten kurtzen CHRONICA dritter Theil, fürstellend: Die merckwürdigsten Welt= und Wunder=Geschichte / so sich in und ausser Europa in diesem noch währenden Land= und Leuth= verderblichen Krieg / so wohl zu Wasser als Lande von Anno 1690 biß 1695 zugetragen. – p. 135f, Hamburg 1695.

DIARIUM praefecturae Scholarum Societatis Jesu. – p. 456v, Archiv Slovenije, Ljubljana.

DRIMMEL, J., GANGL, G., GUTDEUTSCH, R., KOENIG, M. & TRAPP, E: Modellseismische Experimente zur Interpretation makroseismischer Daten aus dem Bereich der Ostalpen. – Zeitschrift für Geophysik, **29** (1973), p. 21–39.

FERRARI, G. & MARMO, C.: Il 'quando' del terremoto. – Quaderni storico nuovo serie 60/3, p. 691ff, 1985.

FIEDLER, G.: Die Erdbebentätigkeit in Südwestdeutschland in den Jahren 1800–1950. – Diss. TH Stuttgart, 152pp., 1954.

GRIMMEL, E. & KOCH, E.: Sicherheit von Kernkraftwerken bei Erdbeben aus geowissenschaftlicher Sicht. – Naturwiss. Rundschau, **35**/10 (1982), p. 400–405.

GROTEFEND, H.: Taschenbuch der Zeitrechnung des deutschen Mittelalters und der Neuzeit. – Hannover 1982.

GUTDEUTSCH, R., MAYER, I., HAMMERL, Ch. & VOCELKA, K.: Erdbeben als historisches Ereignis – Die Rekonstruktion des niederösterreichischen Erdbebens von 1590. – Berlin – Heidelberg – Wien (Springer) 1987.

HAMMERL, Ch.: An example of historical research and methodology of earthquake sources applied to the event of 15th september 1590, – In: Workshop on historical seismicity of central-eastern mediterranean region, p. 95–112, ENEA CRE Casaccia, Rome 1987.

ILLIES, J.H., BAUMGARTNER, H. & HOFFERS, B.: Stress Pattern in the Alpine Foreland. – Tectonophysics, **71** (1981), p. 157–172.

KARNÍK, V. & SZEIDOWITZ, G.: Komárno 1763. – Paper, presented on the 3rd workshop meeting "Historical Earthquakes in Central Europe", Liblice/ČSFR, April 1990.

KEFERSTEIN, Ch.: Versuch eines chronologischen Verzeichnisses der Erdbeben und vulkanischen Ausbrüche seit Anfang unserer Zeitrechnung.– Zeitung für Geognosie, Geologie und Naturgeschichte des Innern der Erde, **4**/3, p. 303, Weimar 1827.

KOZÁK, J. & THOMPSON, M.: Historische Erdbeben in Europa. – Zürich (Schweizerische Rückversicherungs-Gesellschaft) 1991.

KUSTERNIG, A.: Erzählende Quellen des Mittelalters. Die Problematik mittelalterlicher Historiographie am Beispiel der Schlacht bei Dürnkrut und Jedenspeigen 1278. – Wien 1982.

LENTILIUS, R.: Curiosorum oribasii disquisitio de terrae motu anno 1690 d. 24. Novembr. Sueviam et confinia quatiente. – In: Miscellanea curiosa sive Ephemeridum medicophysicarum Germanicarum Academiae Caesareo-Leopoldinae naturae-curiosorum Decuriae III. – Annus Primus, appendix p. 15ff, Leipzig – Frankfurt 1694.

LEYDECKER, G.: Erdbebenkatalog für die Bundesrepublik Deutschland mit Randgebieten für die Jahre 1000–1981. – Geol. Jb., Reihe E, **36**, 1986.

LHOTSKY, A.: Quellenkunde mittelalterlicher Geschichte Österreichs. – Mitteilungen des Instituts für österreichische Geschichtsforschung, Ergänzungsband **19**, 1963.

MÁCZA, M.: Vyvoj Komárna v obrazoch. – Oblastné Podunajské Múzeum Komárno, 1985.

MAYER-ROSA, D. & WECHSLER, E.: Das Erdbeben von Basel 1356. Schäden und seimologische Beurteilung. – In: Historical Earthquakes in Central Europe. – ESC-Monograph V2 (1990) submitted for publication Nuclear Power Reactors. – In: IAEA Publication, Vienna April 1988.

NEUMANN, W.: Zu den Folgen des Erdbebens von 1348, 1.Teil: in Villach. – 24. Jahrbuch des Stadtmuseums, p. 25–39, Villach 1987.

NEUMANN, W.: Zu den Folgen des Erdbebens von 1348, 2.Teil: im Gailtal bei Arnoldstein. – 25. Jahrbuch des Stadtmuseums, p. 9–76, Villach 1988.

POSTMAN, N.: Amuse to death. – Penguin Book, 1980.

POSTPISCHL, D. (Ed.): Catalogo Dei Terremoti Italiani Dall' Anno 1000 al 1980. – Bologna (Consiglio Nazionale Richerche) 1985.

SCHELHAMMER, G.Ch.: De nupero terrae motu. – In: Miscellanea curiosa sive Ephemeridum medico-physicarum Germanicarum Academiae Caesareo Leopoldinae naturae curiosorum Decuriae II, Annus Nonus, p. 246ff, Leipzig – Frankfurt 1690.

SICHERHEITSTECHNISCHE REGELN DES KTA, Auslegung von Kernkraftwerken gegen seismische Einwirkungen, Teil 1: Grundsätze, KTA 2201, Fassung 6/75.

SICHERHEITSTECHNISCHE REGELN DES KTA, Fassung 6/90, (KTA rule 2201.1 version 7/75 and design of the new KTA-rule 6/89).

TOPERCZER, M. & E. TRAPP: Ein Beitrag zur Erdbebengeographie Österreichs. – Aus den Mitteilungen der Erdbeben-Kommission, Neue Folge Nr. **65**, Berlin – Heidelberg – Wien 1950.

WOLF, P. & WOLF, H. : Das Erdbeben in Regensburg von 1062 – Wirklichkeit oder wissenschaftliches Phantom?. – In: Die Oberpfalz, **2/77**, p. 35ff, 1989.

Zeitschrift/Journal: Abhandlungen der Geologischen Bundesanstalt in Wien

Jahr/Year: 1992

Band/Volume: 48

Autor(en)/Author(s): Eisinger Ute, Gutdeutsch R., Hammerl Christa

Artikel/Article: Historical Earthquake Research - an Example of Interdisciplinary Cooperation between Geophysicists and Historians 33-50