

The earthquake of 27th February 1768 in Lower Austria: repair costs and seismic intensity in Wr. Neustadt

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Abstract

During the Age of Enlightenment the importance of administration increased. It left its traces in the official inquiries after natural disasters. For financial and other reasons authorities found it important to record the damage done to buildings by earthquakes. This background reflects the official inquiries after the damaging earthquake of 27th February 1768 in Lower Austria, which includes an important additional piece of information: a record of the respective damage costs in florins per house in Wr. Neustadt. In this study an attempt of quantification is made to relate the damage costs to the respective damage class and intensity according to the EMS-92 scale. The earthquake intensity for Wr. Neustadt as a whole is estimated to be $I = VII$ EMS-92. This result contrasts with older publications, where the intensity VII-VIII or VIII has been assessed.

Key words *historical earthquake – intensity estimation*

1. Introduction

Wr. Neustadt, in the southern part of the Vienna Basin, was often exposed to earthquakes of moderate size, which originated at a NE-SW orientated fault system of the Viennese Basin.

The strongest earthquake, with epicentre near Brunn/Steinfeld, close to Wr. Neustadt, occurred on February, 27th 1768. In fig. 1, taken from Drimmel (1984), Wr. Neustadt belongs to an *area of the highest intensities observed* $VIII \leq I < IX$ MSK. This «area» has been drawn on the basis of the 1768 earthquake. The earthquake catalogue of Toperczer and Trapp (1950) associates this earthquake with an epicentral intensity of VIII MSK.

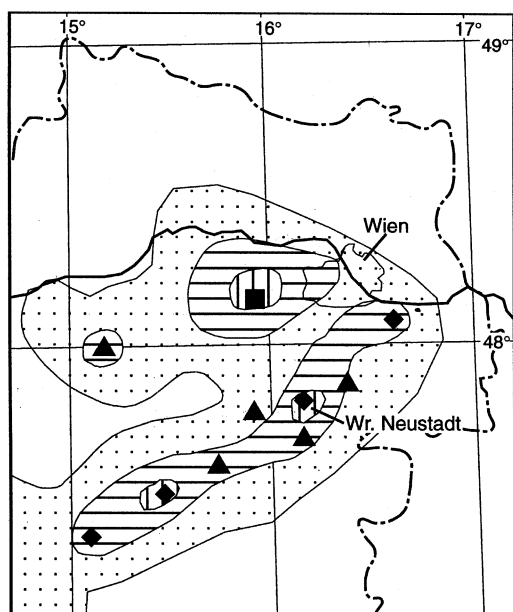
Figure 2 shows the isoseismals of this event, taken from Ariç (1990): here Wr. Neustadt is represented with intensity VIII MSK. In a later interpretation using more data, Eisinger *et al.* (1992) came to a lower value of the intensity in Wr. Neustadt: VII-VIII MSK.

In order to assess a more stable figure a more thorough study was performed. The present study includes the data of official inquiries concerning repair costs and herewith possibly will lead to a more reliable intensity estimate for Wr. Neustadt.

The earthquake of 1768 occurred during the age of Enlightenment in the Austrian-Hungarian monarchy under the Empress Maria Theresa. The importance of administration for the empire was generally realized and increased. This fact is reflected by two official inspections, which were carried out to know the effects and damage done by the earthquake:

– on the one hand – for the first time for this purpose – the Imperial and Royal court mathematician Joseph Nagel (1768) was appointed by the Empress to make inquiries into

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Areas of the highest intensities observed

- 6 ≤ I < 7 MSK
- ▨ 7 ≤ I < 8 MSK
- ▩ 8 ≤ I < 9 MSK

Epicentral intensities

- ▲ 7 ≤ I₀ < 8
- ◆ 8 ≤ I₀ < 9
- 9 ≤ I₀ < 10

Fig. 1. Maximum intensities in the east of Austria from 1201-1983 (from Drimmel, 1984).

the consequences caused by the earthquake. He visited several towns within a radius of about 50 km from the epicenter (Ariç, 1990);

– on the other hand, in the town of Wr. Neustadt a «Specification of suffered damage from cattle-plague and earthquake 1767/1768» (Verzeichnis, 1768) was registered by the municipality of Wr. Neustadt. In both cases it was an official inquiry to gain an impression of the earthquake effects.

The register (Verzeichnis, 1768) is an excellent contemporary source, giving the damage in florins per house in 192 cases (including eight of them from outside the townwall) in Wr. Neustadt. Unfortunately, it does not in-

clude the damage descriptions. The task of transforming these data in terms of macroseismic scale is a typical aspect of the well known problem of the quantification of historical earthquake records and requires special care.

2. Sources

The Imperial and Royal court mathematician Joseph Nagel noticed following on the earthquake consequences in Wr. Neustadt: «I will not repeat in detail how much public and other buildings like the imperial fortress suffered from the earthquake, this is more than well known now ... In consequence of the first earthquake shock, which lasted, after some reports till one minute, vaults and other walls were so damaged, that they partly collapsed or had been pulled down in the following to prevent a greater disaster ... the inhabitants were so lucky, that nobody of them was killed ... they had to put supporting beams in the middle of the church to prevent the collapse of the very tumble-down vault. The south directed main wall of the fortress was displaced by 2 1/2 inches» (Nagel, 1768).

In this connection it should be said, that *e.g.* the two towers of the church, which were at this time in a bad condition, did not collapse.

The Imperial and Royal astronomer P. Hell described the damage to the fortress as following: «... there were cracks in the main walls, all four towers in the corners of the fortress crack along the windows, the windows on the roof fell down, the vaults were displaced, broken and many cracks could be seen, several chimneys were broken... all together the damage was so heavy, that it was not possible any more to live in it [in the fortress]... fortunately nobody in the town was killed or hurt ...» (Extrablatt Wr. Diarium, 1768).

In the fortress the Imperial and Royal military academy was stationed. It has to be said that years before the earthquake, had been sought money from the empress Maria Theresa to restore the fortress because of its bad conditions. In this case information about the repair costs (which are listed) is not very representative of the damage caused by the earthquake.

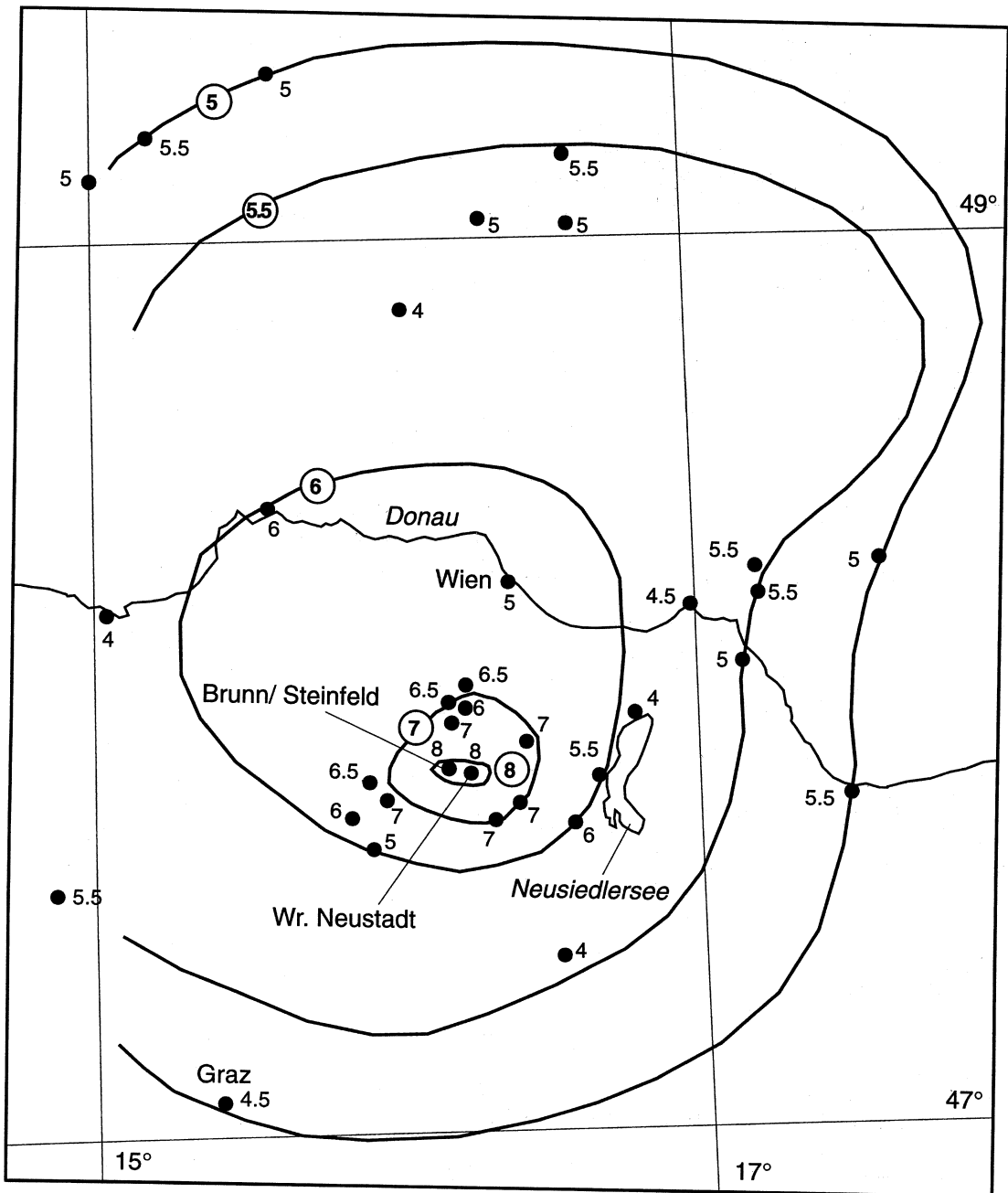


Fig. 2. Isoseismal map of the February 27th, 1768 earthquake in Lower Austria (from Ariç, 1990, modified).

One clergyman of the Carmelite order noted: «... My bed was full of plaster, in another bed there were heavy pieces of the fallen down plaster, four chimneys collapsed partly, no corridor, no room could be found without cracks...» (Wiener Diarium, 1768).

The Carmelites described the damage on their monastery in great detail: «... because nobody was hurt during this big earthquake ...

... One big stone felt down between two persons, who were lying in their beds, without hurting them; in one room a wall collapsed; another wall remained undamaged at the same time another wall outside collapsed and blocked up the door...

... the damage to our church and monastery was big enough ... only the iron or wooden bars to fix the walls cost 244 fl. ...

The most damaged parts were: the spire, the wall near the church above the room where the candles were stored; the walls of the corridor along the three floors: in the first floor the wall near the guest-house of the secular people, in the second floor the wall of the chapel of the 'Infirmarie' and after the first door in front of the floor, in the third floor the wall near the tailoring, ..., the choir-stalls, the cells of the patres and fratres, especially the last cell in the bedroom of the fratres, the bigger stove of the 'Rekreation', the library, the cell in the 'Infirmarie', the 'Refrektorium', stoves, of which three had to be rebuilt ...» (Liber foundationis Neostadiensis).

The chronicle of the Capuchin order of Wr. Neustadt (Wr. Kapuziner, PA Wr. Neustadt) noted that the mass during the Easter week was celebrated in the church of the Carmelite's, this is a hint, that the damage to the Carmelite's church was not substantial.

In the chronicle of the Capuchin order of Wr. Neustadt following was reported: «... No room in the monastery was undamaged, the walls were split either inside or outside, in several rooms inside and outside ... In our church the two chapels were damaged nearly to the collapse, the library looked terrible and totally disordered. In the town no house was without damage, though no house collapsed. All churches suffered more or less damage ... The cathedral had to be supported with beams and

the mass during the Easter week was celebrated in the church of the Carmelite's. ... It is more than miraculous ... that nobody was hurt, even heavy stones of 30 and more pound were fallen down in the beds of the clergymen...» (Wr. Kapuziner, PA Wr. Neustadt, 1768a).

Additional information was found in the chronicle of the Capuchin order of Mödling (Wr. Kapuziner, PA Mödling, 1768b) (30 km north of Wr. Neustadt). It was noted that the earthquake caused damage of 1000 fl. only to the Capuchin monastery in Wr. Neustadt.

The Jesuits note: «... It can be seen as a wonder, that nobody was hurt... The vaults, walls and the roof of the monastery were not damaged by the earthquake but the outhouses suffered big damage». (Litterae Annuae, 1768).

During the assembly of the Council on March 11th two members, one bricklayer and one carpenter, were nominated by the mayor of Wr. Neustadt for each quarter of the city, to visit all the houses to describe and to estimate the damage caused by the earthquake. The observation results of this commission were published in the «Specification...» (Verzeichnis, 1768). In this register 192 citizens were listed, whose properties suffered damage; the total amount of damage was 17058 fl. The following excerpt from the register shows that only the names of the owners and the damage amount has been registered:

| | |
|--------------------|------------|
| 1) ... Meitz | 140 fl. |
| 2) Georg Karner | 18 fl. |
| 3) Stephan Pugn | 35 fl. |
| 4) Johann Gruber | 150 fl. |
| 7) Michael Fentz | 40 fl. |
| 8) Joh. Georg Schr | 14 fl. |
| 9) Anton Sambald | 45 fl. |
| 10) Mathias Kahr | 18 fl. ... |

The chronicler of Wr. Neustadt wrote about the event in the «Altes Stadtbuch» in the following note, which gives an impression of the total damage to all buildings of the city: «There was an earthquake on February 27th 1768 between 3 and 4 o'clock, it lasted for several minutes, ... it caused considerable damage on monasteries, churches and houses of the citizen about 99618 fl.53 Kr. ...» (Altes Stadtbuch, 1768).

3. Interpretation

The record of the earthquake effects for Wr. Neustadt contain sentences and terms, which can be associated with the EMS-92 scale as follows: «... all people fled out of their houses in the street ...» (Wr. Kapuziner, PA Wr. Neustadt; similar in Liber fundationis Neostadiensis) can be compared with the sentence of the EMS-92 (Grünthal *et al.*, 1993) «Most people are frightened and try to run outdoors ...»

The formulation «the library looked terrible and totally disordered» (Wr. Kapuziner, PA Wr. Neustadt) can also be compared with sentences of the EMS-92 (Grünthal *et al.* 1993) «...Furniture is shifted and top-heavy furniture may be overturned. Objects fell from shelves in large number...».

These descriptions correspond to $I = VII$ in the EMS-92 scale. Intensity VII according to the EMS-92 scale means: «many buildings of vulnerability class B-... suffer damage of grade 2. Many buildings of class A and few of class B suffer damage of grade 3, a few buildings of class A suffer damage of grade 4. Damage is particularly noticeable in the upper parts of buildings...».

Damage to buildings appears as a significant testimony as it comprises quantitative information. In this period 436 houses were counted in Wr. Neustadt. As mentioned above $192 - 8 = 184$ citizens' houses inside the town-wall suffered damage from the earthquake. With very few exceptions we know neither the vulnerability class nor the damage grade. Therefore, in most cases, we have no basis to determine the damage rate. What we know is the equivalent loss of money for every damaged house, estimated – or scaled – by a commission in contemporary currency.

We suppose that most buildings can be classified as vulnerability class B, some of class A. This information has been taken from a map in which the construction period of the houses is given (Klaar, 1972) and from still existing houses.

The relation between the repair cost in florins per house and the damage grade according to the EMS-92 scale can be roughly estimated by two different chains of arguments.

The first one takes the historical evidence into account. The second one makes use of the statistical law of data distribution and the descriptions of the most impressive damage done to buildings in Wr. Neustadt.

Studying contemporary sources of the value of currency (*e.g.*, Pribram, 1938) where the contemporary costs for *e.g.* bricks, mortar, the salary of workmen, etc. are listed, one concludes that a direct scale of charge for typical repair work cannot be given. But the analysis of costs suggests that damage of 100 fl/house could correspond to damage grade 2 of the EMS-92 scale. Therefore we apply the method of verification under three sound assumptions as follows:

- 1) damage of about 100 fl/house corresponds to damage grade 2;
- 2) most houses in Wr. Neustadt are associated to vulnerability class B, some to A;
- 3) detailed contemporary descriptions of damage to buildings usually concern the most spectacular ones only; this means that less damaged houses are usually ignored by contemporary writers. Still, these damaged houses may account for the above list.

If the observations verify these assumptions, then we will take them as correct. The assumptions can be checked by plotting the number $n(K)$ of damaged buildings as a function of K , the dual logarithm of the costs, according to (fig. 3)

$$2^K < F \leq 2^{K+1}.$$

The shape of the distribution $n(K)$ = number of houses of class K exhibits a striking similarity to the distribution in fig. B-1 of the EMS-92 scale (Grünthal *et al.*, 1993) here reproduced in fig. 4. Both distributions pass a broad maximum in the center of the figure. The authors understand figure B-1 as a sketch only, visualizing the principle shape of the damage distribution for intensity grade between VII and IX. But one can easily realize the simple relation between damage grade S and the logarithm of the damage costs F per house in florins

$$S = A + B \log (F) \quad (3.1)$$

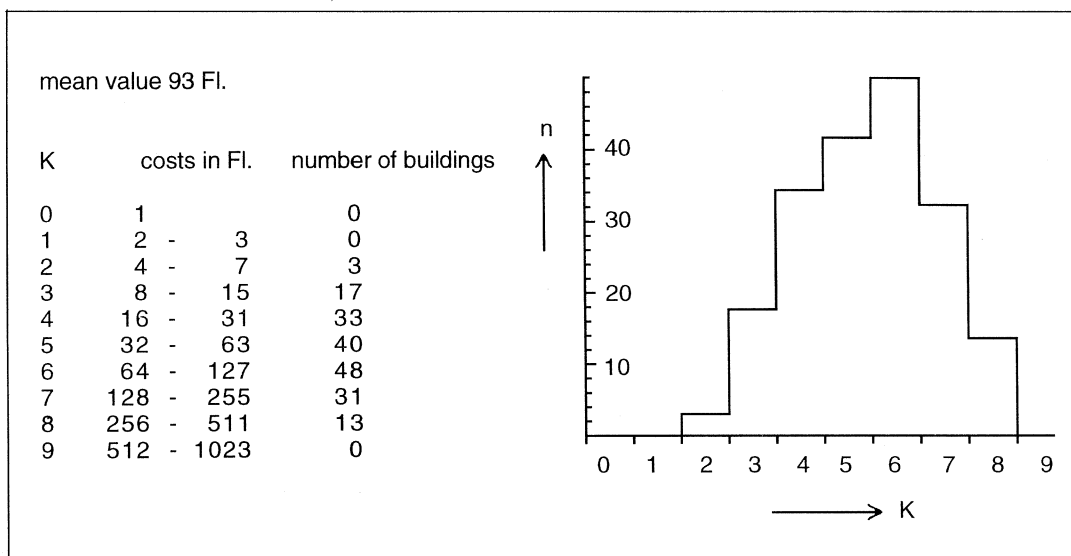
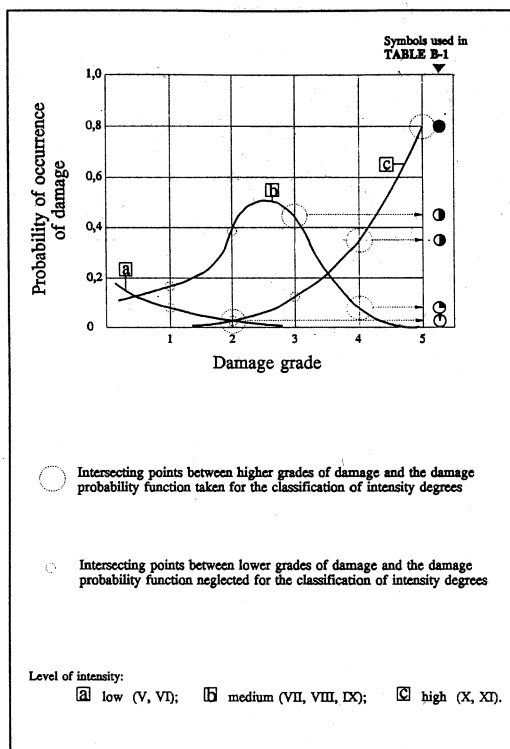


Fig. 3. Frequency distribution of damaged houses in Wr. Neustadt.



valid, for F in florins per house, within the limits of $6 \text{ fl.} \leq F \leq 500 \text{ fl.}$

A and B are constants for the given collection of data, but probably depend on parameters such as the vulnerability class, epoch of the earthquake, local soil conditions etc. A and B can be determined empirically by means of statistics if both damage class S and damage costs F of the affected buildings are available. But, unfortunately, this is not the case here.

Yet, if we use assumptions 1 and 2 and observe that 88 of 436 houses (20%) suffered damage between 32 and 128 fl, «many» buildings suffered damage class 2 and «few» buildings (44 of 436) damage class 3. Table I approximately fits the distribution in fig. 3 and

Fig. 4. Relation between typical frequency distributions of damage grades for different intensity degrees and definitions used in the EMS-92 scale (after Grünthal *et al.*, 1993).

Table I. Data for estimation of the intensity and interpretation of eq. (3.1). Column 4 (F) and 6 (S) have been used to establish eq. (3.2). F = damage cost in florin/house; S = damage class; K = dual log (F).

| Number n | Fraction of 436 | Range of F | F used for eq. (3.2)(*) | $K(F)$ | S used for eq. (3.2) |
|---------------|-----------------|----------------|------------------------------|--------|---------------------------|
| 88 | 20% (many) | 32-128 florin | 10^2 florin | 6.65 | 2 |
| 44 | 10% (few) | 129-512 florin | $4 \cdot 10^2$ florin | 8.65 | 3 |

(*) Due to the nonlinear scale of F the mean value is given within an error of about ± 50 florin.

the relation

$$S = -1.3 + 1.7 \log (F) \quad (3.2)$$

for $6 \text{ fl.} \leq F \leq 500 \text{ fl.}$

Under the restriction above eq. (3.2) holds for the earthquake of Wr. Neustadt 1768 as an approximate relation.

Additional information comes from religious buildings. Due to the sources (see above) one can estimate for the monastery and the church of the Capuchin order grade 3, for the Carmelite's monastery grade 2-3, and for the Carmelite's church grade 2. No damage was noted for the Jesuit's monastery but the out-houses of the Jesuits suffered great damage; in this case it is impossible to assess the damage grade. No information about the Carmelite's nunnery concerning earthquake damage exists. The information that one tower of the Cistercian monastery was damaged and that the pillars of the southern aisle in the church were displaced (Auer *et al.*, 1994) appears doubtful: actually, it was not possible to verify the literature due to the original sources, because the archive in the monastery is not accessible to the public at present.

The sources mention major damage to the cathedral (Wr. Kapuziner, PA Wr. Neustadt), probably of grade 3. For the fortress grade 2-3 can be estimated, but the very bad conditions should be taken into consideration.

These statements fit well to the observation of the damage distribution in Wr. Neustadt and corresponds to $I = \text{VII}$ of the EMS-92 scale. The alternative assumption $I = \text{VIII}$ would imply that few buildings suffered damage grade 4. This is very spectacular damage and would not have been overlooked by contemporaries

and contradicts assumption (3); therefore, the assumption $I = \text{VIII MSK}$ can be ruled out. As a conclusion, an estimate of $I = \text{VII EMS-92}$ for Wr. Neustadt as a whole can be regarded as well established.

4. Conclusions

An example of quantification historical earthquake records is presented by assessing damage class of buildings and intensity of the effects of the earthquake of 1768 in Wr. Neustadt. Strictly speaking, the «key» to solve this task would be to find the relation between the value of contemporary currency and size and type of damage. If this «key» is found, the damage grade according to the EMS-92 scale can be estimated. In the presented example this was not possible, but the assessment was carried out under some basic sound assumptions. The result consists in an intensity estimate for the whole city of Wr. Neustadt different from the one given by previous studies.

Obviously, the material is good enough and the information density is so high that a detailed study useful for calibrating a microzonation of the area of Wr. Neustadt might be attempted, bearing in mind, nevertheless, that in 1768 Wr. Neustadt covered an area smaller than 3 km^2 . Duma (1995) tackled this task using data of both historical and contemporary earthquakes. He came to the general conclusion that zones of relatively high damage from earthquakes of the 20th century coincide with zones of high damage costs of the 1768 event. A more detailed investigation would be of importance and remains for future studies.

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